October 3, 2018 Email to:

Don Wuebbles	Coordinating Lead Author, Climate Science Special Report 2017
David Fahey	Coordinating Lead Author, Climate Science Special Report 2017
Kathy Hibbard	Coordinating Lead Author, Climate Science Special Report 2017
Michael Kuperberg	Executive Director, USGCRP
David Reidmiller	Director of Fourth National Climate Assessment, USGCRP
Patricia Espinosa	Executive secretary, UN Framework Convention on Climate Change
Hoesung Lee	Chair of the Intergovernmental Panel on Climate Change
Thomas Stocker	Co-Chair, IPCC Working Group 1
Dahe Qin	Co-Chair, IPCC Working Group 1
Marsha McNutt	President of the National Academy of Sciences
John Holdren	Former Director, Office of Science and Technology Policy
Margaret Hamburg	President, American Association for the Advancement of Science
Steven Chu	President Elect, American Association for the Advancement of Science
Margaret Leinen	Past President, American Geophysical Union
Roger Wakimoto	President, American Meteorological Society

Subject: A crisis in Science needing immediate attention

I am seeking your help in providing the best science available for informing sound public policy.

Thousands of climate scientists have worked for decades, through the IPCC, the USGCRP, the NAS, and such, with endorsement by the AAAS, AGU, AMS, and numerous other scientific organizations, to convince political leaders that there is "scientific consensus" behind greenhouse-warming theory so that political leaders would take expensive and politically unpopular measures to reduce greenhouse-gas emissions. This tactic proved successful with negotiation of the Paris Agreement in December 2015. Yet agreement on the Paris "rulebook" is faltering and many countries are backing away from their voluntary commitments. World-wide, political groups ignoring climate scientists are increasingly winning elections over groups believing climate scientists.

This is all about to explode in a manner that could be devastating for the credibility of Science. It is now virtually certain that greenhouse-warming theory is mistaken and, in fact, is not even physically possible. These conclusions are based on direct observations of Nature, they agree with the second law of thermodynamics, and they are remarkably clear. A body of matter cannot physically be heated by its own radiation. Heat cannot physically flow from a warm Earth to a warmer Earth and, if it did, the rate of warming is observed to go to zero as the difference in temperature goes to zero. Earth can only be heated effectively by absorbing radiation from a much warmer body, which in our solar system is limited to Sun. Furthermore, a blanket slows the cooling of a body of matter but cannot increase the body's temperature. Otherwise, bodies of matter could heat up spontaneously, providing endless resources of free thermal energy. Something we all know does not happen in Nature. The problem is a fundamental misunderstanding in physics concerning how we think about and quantify heat.

Attached is a draft op-ed providing a short overview of why greenhouse-gas theory is mistaken and how depletion of the ozone layer is observed to cause more very hot, solar, ultraviolet-B radiation to reach Earth's surface, warming Earth. Also attached are a short document explaining the details for intelligent non-scientists and a scientific paper explaining the details for scientists. This paper was rejected without review by JGR Atmospheres for quite unscientific reasons. Shorter versions were similarly rejected by AAAS Science journals and Nature journals without any valid scientific reasoning. Letters from the editors are attached. Many more of my papers have similarly been rejected without review for unscientific reasons. The peer-review system is clearly broken for thoughtful papers questioning the current "scientific consensus".

In 1998, I retired after 27 years as a geophysicist and national program leader at the US Geological Survey. Since 2006, I have had the good fortune to work full time, with minimal distraction, accessing more than 10,000 papers and systematically tracking down the assumptions made in studies of climate and of heat. I have written a book, a key paper, numerous other papers, given many talks available in video, written a major, fully referenced website, spoken with more than 5,000 scientists over three years at my booth in the exhibit halls of AGU, GSA, AMS, and AAPG annual meetings, and appealed directly by email and video to more than 2000 climate scientists involved in writing and reviewing the 2013 IPCC Physical Science Basis report. Since 2015, I have been offering to pay $10,000 from my children's inheritance to the first person or group who can demonstrate by experiment that greenhouse-warming theory actually works.

Several of you have been aware of my work for many years but have chosen, like most leading climate scientists, to dismiss it without discussion. As one of you exclaimed "Peter, there is no way you could be right and all the rest of us are wrong." I agree the statistical odds are miniscule, but science is not done by popular vote or by consensus. As Max Planck, a father of modern physics said in 1936, "new scientific ideas never spring from a communal body, however organized, but rather from the head of an individually inspired researcher who struggles with his problems in lonely thought and unites all his thought on one single point which is his whole world for the moment."

The economic and political costs of the mistaken greenhouse-warming theory are becoming so great and the science is becoming so clear, that, for the sake of humanity, I can no longer accept being ignored. I have in process many ways to bring my scientific observations and conclusions directly to the public and to political leaders. I strongly prefer that my climate observations and conclusions be reviewed and discussed thoroughly within the scientific community and that scientists then step up to the plate and help society deal with a fundamental revolution in science. I want the scientific process to work. I do not have full control of the timing, but I am slowing things down right now in one last effort through this email to reach out for help from leaders in the scientific community.

One of the strengths of Science is that it is self-correcting over time, but only if some scientific minds are open to new data and new insights. Right now, most climate scientists are so weary of fending off politically motivated skeptics that they resist, more than usual, the very difficult task of objectively questioning the paradigm that has been the foundation of their life's work. Soon, however, scientists with their heads in the sand may suffocate, especially in today's political environment.

The closest things to truth in Science are direct observations of Nature that do not depend on some paradigm for correct interpretation. Heat is clearly observed only to flow from warmer to cooler and the rate of heat flow increases with the difference in temperature. As hard as it is to accept right now, greenhouse-warming theory is simply mistaken.

Please consider ways to stimulate thoughtful discussion on why there are problems with greenhouse-warming theory and what else is causing observed global warming. You are each welcome to distribute this email and attachments for review and discussion in any way you see fit. I would be happy to interact with any individuals or groups open to serious scientific discussion on this matter.

Time is of the essence. The world is on the verge of wasting tens of trillions of dollars, hastened by some scientists claiming we must reduce greenhouse emissions immediately to prevent major disaster. The longer it takes scientists to face up to reality, the more bitter the response is likely to be from those who feel they have been misled by Science.

I would sincerely appreciate your help. I look forward to your recommendations. Thank you for your consideration.

Sincerely,

Peter

October 3, 2018
From: David Fahey
To: Peter Ward, et al.
Peter,

Your persistence and commitment can only be admired while your theories and conclusions cannot. Speaking for myself, and perhaps all of the email recipients, I can agree with one of your statements, namely that 'the statistical odds are minuscule' that 'you could be right and the rest of us are wrong.' Minuscule is zero in my assessment. As we have discussed before, your conclusions concerning radiation and heat transfer have implications that go far beyond climate warming because they imply lack of understanding of many fundamental aspects of our physical world. I encourage you to take seriously the judgement of the journal editors, along with many others, and reexamine your reasoning and strive to 'substantiate your arguments with rigorous quantitative calculations or analysis of measurements' (JGR Editor).

Cheers
Dave

From: Peter Ward
To: David Fahey et al.
Dave,

You continue to ignore reality. The science is remarkably clear. There is a fundamental misunderstanding about what heat is and how heat should be quantified. Kindly explain what is wrong with any of the following:

1. Temperature in matter, as shown by Planck's law, is the result of a broad continuum or spectrum of frequencies of oscillation of the bonds holding matter together.

2. Planck's law shows that radiation from a hotter body contains higher amplitudes of oscillation at every frequency of oscillation and much higher frequencies of oscillation with high amplitudes of oscillation.

3. A body of matter, therefore, cannot physically be heated by its own radiation, which does not contain the higher amplitudes of oscillation required for a higher temperature.

4. Solar radiation includes higher-frequency visible and ultraviolet frequencies not found in lower-frequency terrestrial radiation. No amount of terrestrial radiation for any length of time can generate light that is visible or cause sunburn.

5. Planck's law shows that heat, that which a body of matter must absorb to increase its temperature, is a broad continuum or spectrum of frequencies of oscillation of the bonds holding matter together. Heat is the difference between a Planck curve for a warmer temperature minus a Planck curve for a cooler temperature. Heat is a continuum that cannot be described in watts per square meter.

6. Heat only flows from a warm body to a cooler body; the second law of thermodynamics.

7. Heat, therefore, cannot physically flow from a warm Earth to a warmer Earth.

8. If the Planck-Einstein relation, E=hv, accurately describes the energy in electromagnetic radiation, which is widely agreed, and since v is well-known to be a continuum of frequencies making up much of the electromagnetic spectrum, and h is the Planck constant, then E must be a continuum, not a photon as widely assumed. E in thermal radiation cannot be quantified by a single number of watts per square meter.

Again, note that I am showing that all "rigorous quantitative calculations or analysis of measurements" published in JGR Atmospheres and elsewhere are based on mistaken mathematics—on a fundamental misunderstanding about what heat is. Heat is a continuum, not a discrete number of watts per square meter.

This is all described in detail in the attachments. Prove me wrong.

Peter

No other response of any kind was received from anyone.

Greenhouse-warming theory:
An extremely expensive scientific mistake

A revolution in the scientific understanding of heat shows that greenhouse-warming theory is not physically possible. Reducing greenhouse-gas emissions will have no perceptible effect on reducing observed global warming.

Greenhouse gases have been observed since 1859 to absorb certain limited frequencies of infrared energy radiated by Earth. Greenhouse-warming theory proposes that this absorbed radiation is either re-emitted back to Earth or acts like a blanket slowing the cooling of Earth. Absorbed thermal radiation, however, can only warm a body of matter to the temperature of the source of the radiation. Heat is well observed to flow spontaneously only from a hotter body of matter to a cooler body. It is physically impossible for heat to flow spontaneously from a warm Earth to a warmer Earth. It is physically impossible for a blanket to make a body hotter than it already is. Otherwise, bodies of matter could heat up spontaneously, providing endless resources of free thermal energy.

The fundamental scientific mistake is in the way we think about and calculate heat. Heat is what a body of matter must absorb to increase its temperature and radiate to lower its temperature. Physicists, by the end of the 18th century, began thinking of heat as the rate of flow of some undefined generic thing. Today physicists are taught to never refer to heat as a physical thing—it is a flux, but a flux of what?

Currently heat is thought of as an amount or quantity of thermal energy flowing per second, such as the radiation from a 100-watt light bulb. Scientists currently think that the more watts of radiation absorbed by a body, the warmer the body will become.

But all radiation is not created equal. The ability of radiation to warm matter is determined by the temperature of the radiating body as shown clearly in 1900 by Max Planck, one of the fathers of modern physics. Planck and others observed that temperature in matter results from a very broad spectrum or continuum of frequencies of oscillation of all the bonds that hold matter together.

What has become known as Planck's empirical law shows that the higher the temperature, the higher the amplitude of oscillation at each and every frequency of oscillation and also the broader the continuum of frequencies of oscillation with significant amplitude of oscillation. Heat is now understood as the transfer by resonance of these amplitudes of oscillation at each and every frequency of oscillation.

Sun, which is 20-times hotter than Earth, radiates ultraviolet frequencies that are hot enough to cause sunburn, skin cancer, cataracts, and mutations of DNA. All available infrared radiation emitted by Earth, over any period of time, cannot cause these thermal effects.

Sun clearly heats Earth. What is well-understood, but not widely discussed, is that most of Sun's hottest ultraviolet radiation is absorbed in the upper atmosphere. High-frequency, high-thermal-energy, ultraviolet-C radiation ionizes the ionosphere and heats the stratosphere. Lower-frequency, lower-thermal-energy, ultraviolet-B radiation is absorbed by ozone, heating the ozone layer.

When ozone is depleted, less ultraviolet-B radiation is absorbed within the ozone layer, causing well-observed cooling of the ozone layer. Meanwhile, more ultraviolet-B radiation than normal is clearly measured to reach Earth, where it is observed to raise your risk of sunburn and skin cancer. Ultraviolet-B penetrates oceans tens of meters, efficiently warming oceans and sunburning coral. In this way, global warming is determined primarily by how much very hot ultraviolet-B radiation penetrates Earth's atmosphere all the way to Earth's surface.

Direct observations show unequivocally that we humans caused massive ozone depletion by manufacturing large amounts of chlorofluorocarbon gases (CFCs) used as refrigerants, spray-can propellants, solvents, and foam-blowing agents. These CFCs began causing global warming around 1970. In 1985, after discovering the Antarctic Ozone Hole, we humans passed the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer, mandating cutbacks in CFC manufacturing. Sure enough, by 1998, the Montreal Protocol had stopped global warming from increasing.

Five times more rapid warming from 2014 to 2016 was contemporaneous with ozone depletion caused by emission of chlorine and bromine from Bárðarbunga volcano in central Iceland, the largest, effusive, basaltic, volcanic eruption since 1783. These types of sub-aerial, basaltic eruptions, covering hundreds of square miles of land to millions of square miles of land, have been contemporaneous with periods of major ozone depletion and rapid global warming throughout Earth history—the larger the eruption, the greater the warming, and the longer the warming lasts.

Most climate scientists today are genuinely convinced, beyond a reasonable doubt, that global warming is caused by increasing emissions of greenhouse-gases due to humans burning fossil fuels. They are especially concerned that anticipated levels of greenhouse-gas emissions within the next few decades could seriously threaten life on Earth.

For these reasons, thousands of climate scientists have spent decades trying to demonstrate "scientific consensus" regarding greenhouse-warming theory to convince political leaders to take expensive and politically unpopular steps to reduce greenhouse-gas emissions. This tactic succeeded in December 2015 when nearly all countries in the world agreed in Paris to reduce greenhouse-gas emissions to keep the increase in global average temperature well below 2 °C above pre-industrial levels.

This well-meaning drive for consensus, however, has stifled debate. Consensus is the stuff of politics while debate is the stuff of science. As Michael Crichton said at Caltech in 2003, "the greatest scientists in history are great precisely because they broke with the consensus. There is no such thing as consensus science. If it's consensus, it isn't science. If it's science, it isn't consensus. Period."

Science is done by detailed observations of nature that are interpreted based on some worldview, some conceptual scheme, some paradigm. Thomas Kuhn, a physicist and philosopher of science, argued in his very influential book The Structure of Scientific Revolutions, that "successive transition from one paradigm to another via revolution is the usual developmental pattern of mature science."

Changing paradigm, changing a core belief, has always been difficult. Scientific revolutions normally take years to decades to even centuries to catch on. For climate change, however, time is of the essence because many scientists are insisting that we must act now to reduce greenhouse-gas emissions before it is too late.

Implementing the Paris Agreement is expected to cost tens of trillions of dollars as well as a great deal of political capital. Many countries are already backing away from their voluntary commitments. World-wide, political groups ignoring climate scientists are increasingly winning elections over groups believing the scientists.

Meanwhile, climate scientists, hiding behind "the consensus", are refusing to even consider the possibility that there could be the slightest problem with greenhouse warming theory. Many leading scientific journals are refusing to even send out for review papers questioning greenhouse-warming theory. Many science reporters refuse to interview scientists questioning greenhouse theory.

It is time for my fellow scientists to step up to the plate—to understand, evaluate, and take ownership of this major revolution in science before world governments waste tens of trillions of dollars. We need to stop the global black market in CFCs, stop China's flouting of the Montreal Protocol, and research other ways to reduce ozone depletion. Meanwhile the oceans continue to warm, glaciers continue to melt, and sea level continues to rise.

Dr. Peter Langdon Ward was a geophysicist and program leader at the U.S. Geological Survey for 27 years. He has worked full time in retirement since 2006 tracking down enigmas in climate science. He is author of "What Really Causes Global Warming? Greenhouse Gases or Ozone Depletion?", numerous scientific papers, the website WhyClimateChanges.com and #WhyClimateChanges.

Greenhouse Warming Theory Is Not Physically Possible

Observed warming throughout Earth history is explained clearly and in detail by depletion of the ozone layer allowing more solar ultraviolet-B thermal energy to reach Earth

Dr. Peter Langdon Ward
United States Geological Survey retired

Clear, unambiguous observations of Nature show that greenhouse warming theory is based on a fundamental misunderstanding in physics about what heat is physically and how heat flows through matter, air, and space.

Heat is what a body of matter must absorb to become warmer and must lose to become cooler. Heat, as shown below, is a broad spectrum of thermal energies, most of which are not absorbed by greenhouse gases.

Furthermore, heat is well known to flow spontaneously only from warmer bodies of matter to cooler bodies of matter where the flux of heat that flows decreases to zero as the difference in temperature decreases to zero. It is physically impossible, therefore, for heat radiated by Earth to flow back to the planet's surface, making Earth warmer in any of the ways assumed in greenhouse warming theory. A body of matter cannot physically be warmed by its own radiation; otherwise bodies, under the right conditions, could spontaneously heat up, providing an endless supply of free thermal energy.

Earth can only be warmed by absorbing radiation from a much hotter body, of which Sun is the only example in our solar system. It turns out that average global temperatures are determined primarily by how efficiently different frequencies of solar radiation penetrate Earth's atmosphere.

A fundamental misunderstanding about heat

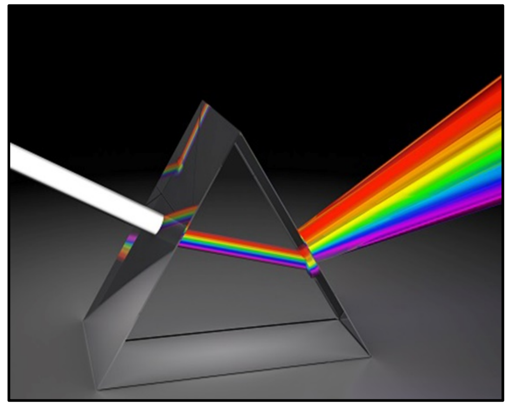
The roots of this misunderstanding are deep, extending back to the 1700s—at least a century before scientists began to understand the atomic and molecular nature of matter. Physicists at that time had no idea what thermal energy in matter was physically. They simply thought of thermal energy as some generic thing contained within matter as they would think of a liquid contained in a tank. The more of this generic thermal energy absorbed, the hotter the matter was assumed to become. Thus, they thought of heat as an <u>amount</u> of some undefined thing called thermal energy flowing per second across a surface ultimately in units of watts per square meter.

Thinking of thermal energy only as an amount has been a reasonable approximation, even today, when the temperatures of the bodies of matter involved are similar. For greenhouse warming theory, however, this thinking breaks down catastrophically because Sun, which clearly warms Earth, is twenty times hotter than Earth.

Climate scientists currently assume that thermal energy radiated by Sun is the same physical thing as thermal energy radiated by Earth except Sun radiates a much greater <u>amount</u> of it. Yet today we observe clearly that the physical properties of radiation from Sun are significantly different from the physical properties of radiation from Earth. Solar radiation, even in small amounts, includes visible light and ultraviolet radiation, which causes sunburn, skin cancer, cataracts, and mutations of DNA. Radiation from Earth, on the other hand, does not include visible light and cannot cause any of these chemical changes no matter how great the amount. Thus, contrary to current thinking in terms of simple amount, the physical properties of radiation from Sun are actually distinctly different from the physical properties of radiation from Earth.

The physical properties of heat

Visible light has two main physical properties: frequency of oscillation, which is equivalent to color, and amplitude of oscillation, which is equivalent to intensity or brightness of that color. Visible light, in fact, contains a whole spectrum of colors that we see in a rainbow or when white light is passed through a prism, ranging from different shades of red, to orange, to yellow, to green, to blue, to violet.



*A **prism** disperses white light into its frequency components.*

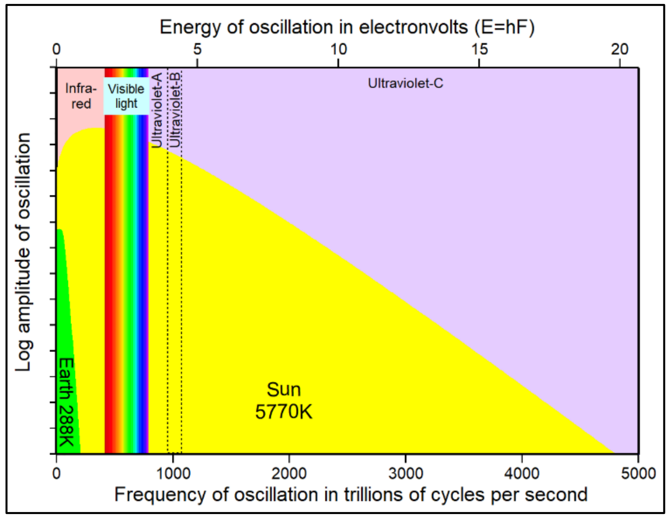
Thermal radiation, the radiation from a body of matter caused by its temperature, is well known to be the electromagnetic spectrum ranging from extremely low frequency radio signals oscillating at a few cycles per second, to microwaves, to infrared radiation, to visible light oscillating at hundreds of trillions of cycles per second, to ultraviolet radiation, to X-rays, to gamma rays oscillating at nearly one billion trillion cycles per second.

All these frequencies of oscillation are always present simultaneously in matter, air and space, but depending on the temperature of the emitting body, the amplitude of oscillation at each frequency of oscillation ranges from insignificant to dominant. In other words, these amplitudes of oscillation increase, especially at high frequencies, with increasing temperature of the radiating body of matter.

By the late 1800s, many physicists were measuring the physical properties of radiation. In 1900, Max Planck, one of the fathers of modern physics, developed, by trial and error, an equation, now known as Planck's law, that accurately calculates all observations of the distribution of frequencies of oscillation and their amplitudes of oscillation as a function of the temperature of the radiating body.

Oscillation of what? By the late 1800s, the atomic revolution in science was underway with the discovery of electrons in 1897 and the nucleus of atoms in 1909. Physicists and chemists began to understand the structure of atoms and that matter consists of atoms bonded together into molecules. These bonds are not rigid. In the 20th century, it became clear that thermal energy within matter consists of the simultaneous oscillation of all of these bonds holding matter together. Each bond oscillates between forces of repulsion as atoms get too close and forces of attraction as atoms get farther apart.

Planck's law shows that the higher the temperature of the body, the greater the amplitude of oscillation at each frequency of oscillation and the greater the frequencies of oscillation that have the greatest amplitudes of oscillation. Furthermore, the greater the amplitude of oscillation, the greater the average length of the bond and, therefore, the greater the volume of the matter. Most materials are observed to expand when they are heated.



***Planck's law** is an equation derived by experiment that calculates the observed amplitude of oscillation at each frequency of oscillation for radiation from a body of matter at a given absolute temperature in units of kelvin. The hotter the body, the higher the amplitude of oscillation at each and every frequency of oscillation and the higher the frequencies with major amplitudes. Note that the frequencies emitted by Earth (green) are a tiny subset of the frequencies emitted by Sun (yellow).*

The physical properties of transferred heat, therefore, vary significantly with the temperature of the radiating body. Heat radiated by the very hot Sun (yellow in the figure) contains much higher frequencies of oscillation and much higher amplitudes of oscillation at each and every frequency of oscillation than heat radiated by the much cooler Earth (green).

It is these much higher frequencies of oscillation in the ultraviolet-B range that cause sunburn, skin cancer, cataracts, and even mutations—chemical reactions that cannot be caused by any amount of infrared radiation from Earth. In this way, the average temperature of Earth's surface is determined by how efficiently these much higher frequencies of oscillation penetrate Earth's atmosphere.

What is thermal energy physically?

In 1900, Planck was able to write his law by postulating that thermal energy (E) equals a constant (h) times frequency (F), where E=hF. This simple equation says that thermal energy is physically identical to frequency of oscillation times a scaling constant (h, the Planck constant), which simply changes the units of measure from cycles per second to energy measured in either joules or electronvolts.

In 1905, Albert Einstein used this equation, E=hF, to describe the photoelectric effect where light, with a color above some minimum frequency in the blue to violet color range, is observed to release electrons from a fresh, unoxidized, metallic surface. In this usage, E is the minimum level of energy, the minimum frequency of oscillation, required to break the bond holding an electron to a molecule of some specific metal. Atmospheric chemists similarly use this equation, E=hF, to specify the minimum level of energy, the minimum frequency of oscillation, required to break a chemical bond that is holding together, for example, the two atoms of an oxygen molecule. Einstein visualized E as a discrete number, an amount of energy, a quantum of energy, a particle of light, which soon became known as a photon. Einstein's concept of a "light quantum" in 1905, led to the development of modern quantum physics and modern particle physics.

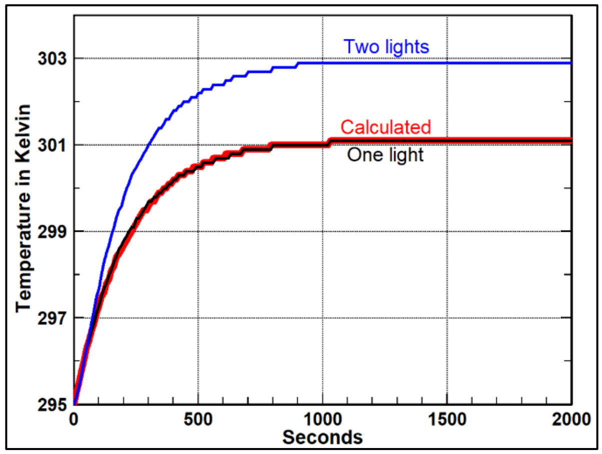
This simple equation, E=hF, however, contains a most surprising and inconvenient truth. When applied to heat, frequency (F) is the electromagnetic spectrum, well-known to be a spectrum of frequencies of thermal oscillations, as described above. A constant (h) times a spectrum of frequencies of oscillation must equal a spectrum of energies of oscillation. Thermal energy E, therefore, is not a quantum, a photon, or a particle—it is a spectrum of energies where each frequency of oscillation has a different energy of oscillation—the higher the frequency, the higher the energy of oscillation. Each frequency is the frequency of oscillation of a single physical oscillator, which is a single degree of freedom of motion of a single bond. Each oscillator is oscillating at a specific frequency, which is a specific level of energy (E=hF). Energy is not limited to be an integer multiple of some basic quantum value of energy as assumed in quantum physics. An individual discrete energy can be any value. Thermal energy is the spectrum of all discrete energies of all degrees of freedom of motion of all physically discrete bonds oscillating simultaneously.

In summary, Planck's law calculates, based on the temperature of the radiating body of matter, the observed amplitude of oscillation at each frequency of oscillation throughout the whole electromagnetic spectrum. Thermal energy at each frequency of oscillation is the same physical thing as the frequency of oscillation. Heat, however, that which must be absorbed to increase the temperature of a body of matter, is the difference between the Planck curve for the final temperature minus the Planck curve for the starting temperature. Heat, therefore, is a spectrum of values of the difference in amplitudes of oscillation at each frequency of oscillation. A body of matter is heated by absorbing radiation that contains greater amplitudes of oscillation at each frequency of oscillation throughout the whole electromagnetic spectrum that is being radiated. This radiation, this heat, can, at best, raise the temperature of the absorbing body only as high as the temperature of the radiating body.

Heat flows by resonance

Heat is observed to flow spontaneously through matter, through air, and through space from higher temperature to lower temperature. How can a spectrum of frequencies flow? The only option I know of is by resonance.

Resonance is a widely observed physical process whereby two discrete physical oscillators, oscillating at nearly identical frequencies, average their amplitudes of oscillation. In the simplest case, one-half the difference in amplitude of oscillation moves from the higher amplitude oscillator to the lower amplitude oscillator. From Planck's law, this means at each frequency of oscillation that some amplitude of oscillation moves from the higher temperature oscillator to the lower temperature oscillator, in effect averaging the two amplitudes. When resonance occurs simultaneously across all frequencies of oscillation, the two temperatures of two similar bodies are averaged, as typically observed. The greater the difference in temperature, the greater the amount of amplitude that flows at each frequency. Heat is the flow of this broad spectrum of amplitudes. The greater the difference in temperature, the greater the flow of heat, the greater the flux of heat, which is also typically observed.



The rate of warming, the rate heat flows, decreases with decreasing difference in temperature forming an asymptotic curve. The black line shows temperature increase of a small black object caused by radiation from a light bulb. The blue line shows similar warming caused by two identical light bulbs. The red line shows the temperature calculated by adding 4.6% times the ending temperature minus the existing temperature at each 10-second interval.

Resonance can occur by the physical touching of two oscillators and thus by conduction, but it is also observed to occur across air and space by electromagnetic communication. A radio station radiates (broadcasts) at a specific frequency. We tune a radio receiver to resonate at that specific frequency, thereby receiving a signal with most amplitude just from that single transmitter.

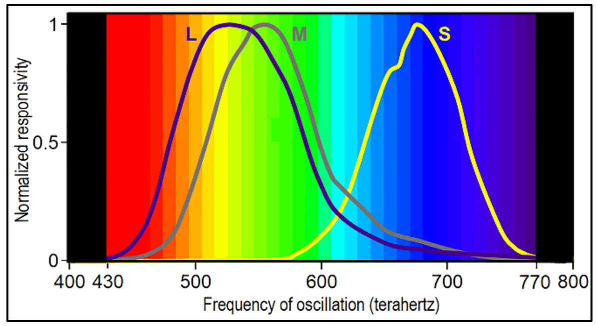
Electromagnetic communication is made possible by the observation that an oscillating electric charge induces what we think of as an oscillating electric field. This oscillating electric field then induces an oscillating magnetic field. The oscillating magnetic field then induces an oscillating electric field, and so on, providing a way for resonance to occur. We still have much to learn about the detailed physics of electromagnetic communication—about precisely how resonance occurs.

Resonance is all around us

We all hear by resonance. The frequencies of sounds in air resonate with tiny hairs in our inner ear, sending signals to our brain that let us differentiate all the different frequencies. Similarly, a tuning fork in air resonates when an identical tuning fork oscillates nearby.

We all experience resonance when pushing a child on a swing. If we push at the same frequency as the swing is moving, the swing will go higher and higher.

We all see via resonance. When sunlight shines on a green leaf, for example, most frequencies of radiation are absorbed by the leaf, but the green frequencies are, in effect, reflected. Well, actually the color-forming bonds resonate with the light source at the frequencies of their natural color green. These color-forming oscillators then resonate with three different cells in the cones of our eyes (L, M, and S), each of which have a different amplitude response to frequency. Our brain can then differentiate ten million different colors just from these three amplitude responses in the same way that the color of a pixel on your RGB computer screen is determined by three different shades of Red, Green, and Blue primary colors.



Three different types of cone cells in our eyes (L, M, and S) respond differently when resonating with different colors.

For the propagation of heat, resonance is occurring at each and every frequency simultaneously. On a cold, clear night, bonds oscillating on the surface of Earth resonate with much colder bonds in deep space, leading to the transfer of a great deal of heat. When a cloud is present, often heated by the Sun, the difference in temperature with Earth is much smaller, so that much less heat is transferred.

Resonance is the process in Nature that quantum physicists try to explain as quantum entanglement, where the physical state of something here influences the physical state of something at an arbitrary distance over there with no visible connection between them. Resonance is all around us, it occurs by line of sight, and it is the primary way that living organisms sense the physical world.

The thermal effects of radiation decrease with distance

Frequency of oscillation in radiation and the chemical energy E=hF in radiation are clearly observed not to change with distance, even over galactic distances, except for a small shift when the radiating body is moving relative to the absorbing body—known as the Doppler effect. Amplitude of oscillation in radiation similarly does not change with distance—it only changes through resonance. There is no friction in space to change frequency or amplitude. The heat transferred, however, is observed to decrease with the square of the distance travelled and with decreasing angle of the absorbing surface to the line of sight.

A body of matter looks smaller at a distance because the "size" we see is the solid angle subtended by the distant body at our eye. This solid angle is inversely proportional to the square of the distance. When two bodies are close together, each bond oscillator on the emitting surface resonates with a similar bond oscillator on the absorbing surface. As the bodies move apart, the percent of oscillators on the absorbing surface that resonate, the density of oscillators on the absorbing surface that resonate, decreases proportionally to the square of the distance. In this way, each bond oscillator on the absorbing surface must share by conduction the amplitude of oscillation transferred with an increasing number of bond oscillators that do not resonate with the distant oscillator. There is a similar effect, as the angle of the absorbing surface to the line of sight decreases from ninety degrees to zero.

What is the velocity of light?

For more than 2500 years, natural philosophers and scientists have argued whether electromagnetic radiation, a small subset of which is visible light, travels through space as a wave, a particle, or, in modern physics, via some mixture of both called wave-particle duality. These three alternatives are hard to understand physically. Waves travel by deforming a medium such as water or rock, and physicists have proven that there is no light-conducting medium in space. There are no particles of light as explained above. E=hF is a spectrum, not a quantum. Furthermore, waves and particles are physical things that we can see, while we cannot see light until it is absorbed by matter. Why do we insist on explaining things we cannot see in terms of waves and particles that we can visualize? We cannot see radio signals because each is a specific frequency.

The apparent velocity of light is measured to be a very large value, nearly three hundred thousand kilometers per second. Our current experience with waves and particles makes it hard to conceive of how they could move physically at such a high velocity and how this velocity could be constant. Recognizing that light travels by resonance suggests that what we think of as the constant velocity of light might simply be the very short time it takes for resonance to happen via line of sight from close at hand to galactic distances.

Greenhouse gases absorb some thermal radiation but not heat

Heat is a very broad spectrum of frequencies of oscillation with amplitudes of oscillation described by the Planck's law curve based on the temperature of the radiating body minus the Planck's law curve based on the temperature of the absorbing body. Greenhouse gases, however, are clearly observed to absorb only very small parts of this spectrum. Carbon dioxide, for example, simply absorbs the resonant frequencies of its bonds that make up less than 16% of the frequencies in the spectrum required to constitute the heat radiated by Earth. If you have 16% of a person, you do not have a person. In the same way, greenhouse gases do not absorb heat—they just absorb some oscillatory energy into the molecular bonds, which has no direct effect on air temperature.

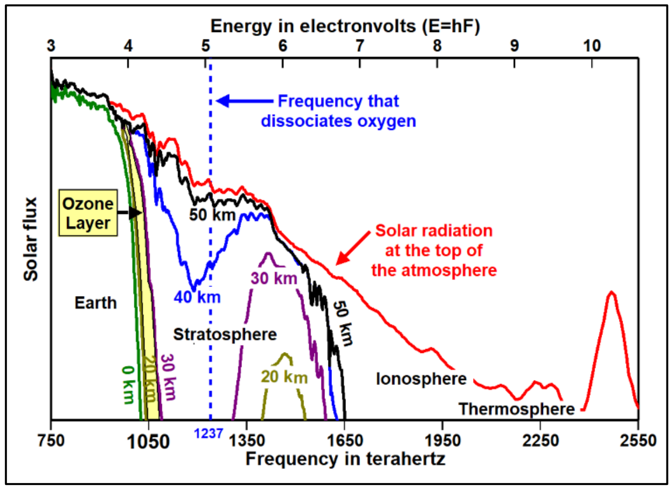
Temperature in air is well-known to be determined by the average kinetic energy of the independent movements of all air molecules travelling and colliding in random directions through space. To convert radiant energy absorbed into the bonds holding the molecule together to air temperature, we must assume that the absorbed oscillatory bond energy is converted through myriads of collisions to kinetic energy of motion of all air molecules. Even if such conversions actually occur efficiently, which they probably do not, the kinetic energy from a single carbon dioxide molecule must still be shared with 2500 other gas molecules because carbon dioxide makes up only 0.04% of air.

Furthermore, Planck's law shows us that the only way that radiation can warm a body of matter, is if the radiation comes from a hotter body that has bonds oscillating at higher amplitudes of oscillation for each and every frequency of oscillation. There is no physical way, without adding heat from a hotter body, for radiation from Earth to have its amplitude of oscillation at every frequency of oscillation increased so that it could warm Earth's surface. Heat cannot flow by resonance from a warm body of matter to a warmer body of matter. Terrestrial radiation does not contain high enough amplitude of oscillation at each and every frequency of oscillation to warm Earth. Greenhouse-warming theory is not physically possible.

Humans most likely caused observed global warming from 1970 to 1998

Solar radiation is well observed to warm Earth every day. Solar radiation, as shown by Planck's law, contains significantly larger amplitudes of oscillation than radiation from Earth at each and every frequency of oscillation.

Ultraviolet-C frequencies of solar radiation are nearly all absorbed in the stratosphere, causing dissociation of oxygen molecules and leading to the formation of ozone molecules. Then ultraviolet-B radiation causes dissociation of ozone molecules in the lower stratosphere in an endless oxygen-ozone cycle that continually forms and destroys the ozone layer every 8.3 days on average. Dissociation causes a molecular bond to come apart, allowing the molecular pieces to fly apart at very high velocity. Dissociation, in this way, converts all energy in the chemical bond directly into kinetic energy of motion, efficiently raising air temperature.



The highest energy solar radiation with frequencies greater than about 1050 terahertz are nearly all absorbed in the atmosphere at altitudes above 20 km.

In this way, the ozone layer protects life on Earth from Sun's hottest, most damaging ultraviolet-C and ultraviolet-B radiation. When the amount of ozone in the ozone layer is decreased, when ozone is depleted, less ultraviolet-B radiation is absorbed in the ozone layer, cooling the ozone layer as observed, and more ultraviolet-B is measured to reach Earth's surface, warming Earth, as observed. Ultraviolet-B radiation penetrates oceans tens of meters, efficiently increasing ocean heat content and sunburning corals.

On land, however, ultraviolet-B radiation is absorbed warming the surface during the daytime, but much of this warmth can be radiated back as infrared radiation at night. In heavily populated areas, however, ground-level ozone pollution is formed in the presence of sunlight by chemical reactions between oxides of nitrogen and volatile organic compounds. When ultraviolet-B radiation dissociates this ground-level ozone pollution, air temperatures rise. This dissociation appears to explain why global warming from 1970 to 1998 was twice as great in the northern hemisphere as in the southern hemisphere because the northern hemisphere contains eighty-eight percent of global population and most air pollution.

Furthermore, ozone depletion is greatest within the Arctic and Antarctic circles, explaining widely observed arctic amplification of global warming and why the greatest warming since 1970 observed anywhere on Earth was along the Antarctic Peninsula. In addition, ozone depletion is greatest during late winter/early spring, raising global minimum average temperatures more than global maximum average temperatures.

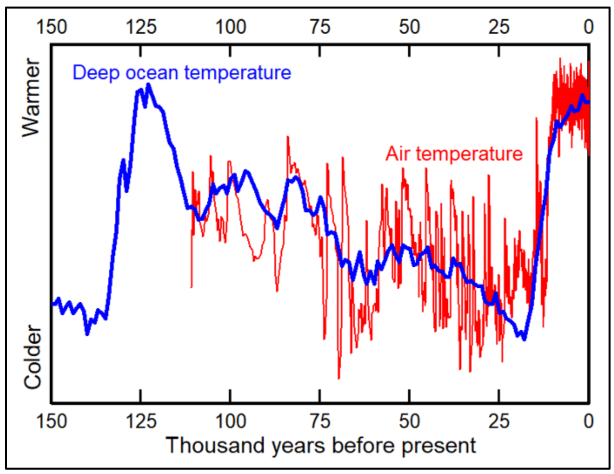
Humans depleted the ozone layer from 1970 to 1995 by manufacturing chlorofluorocarbon gases (CFCs) used widely for refrigerants, spray-can propellants, solvents, and such. When these CFCs rise into the stratosphere, they are broken down by ultraviolet radiation, releasing chlorine atoms. One atom of chlorine in the ozone layer has been shown by three Nobel laureates to catalyze numerous heterogeneous chemical processes that can destroy more than 100,000 molecules of ozone. Thus, ozone depletion is the Achilles heel of the climate system.

When the Antarctic ozone hole was discovered in 1985, scientists and political leaders moved quickly to pass the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer, which mandated rapid cutback in manufacturing of CFCs. By 1993, the increase in CFCs in the atmosphere stopped. By 1995, the increase in ozone depletion stopped. By 1998, the increase in average global temperature stopped for 16 years. Humans appear to have caused global warming by manufacturing CFCs and humans appear also to have stopped the increase in global warming by limiting CFC production.

CFCs are very stable molecules that remain in the atmosphere for many decades. Ozone depletion, therefore, is not likely to be reduced to 1970 levels for many more decades. This natural decay is slowed by an ongoing black market in CFC gases especially in lesser-developed countries and the recent discovery that insulating-foam-blowing industries in China are ignoring the Montreal Protocol. As long as ozone remains depleted, increased ultraviolet-B radiation sublimates snow on the surfaces of glaciers and warms the oceans very efficiently.

Volcanic eruptions both cool and warm Earth

Volcanic eruptions also deliver chlorine and bromine gases into the lower stratosphere where they are observed to deplete ozone, causing short-term warming. Big, explosive eruptions, however, also form sulfuric-acid aerosols in the lower stratosphere that reflect and scatter sunlight, causing net global cooling of about one-half degree centigrade for two to four years. This short-term cooling of the whole ocean surface is modeled to reduce ocean temperatures for as long as a century. That is why several major explosive eruptions per century, continuing over tens of thousands of years, are observed to cool oceans incrementally down into ice-age conditions (blue line for deep ocean temperature in the figure).



Average deep ocean temperature (blue) and air temperature in Greenland (red) during the past 150,000 years.

Hot chlorine and bromine gases rising from basaltic lava flows, on the other hand, are observed to cause sudden global warming but form little if any cooling aerosols. Rapid global warming from 2014 to 2016 appears to have been caused by the slow, effusive eruption of the volcano Bárðarbunga in Iceland, which spread basaltic lava over an area of 85 square kilometers within six months, the largest basalt flow since 1783. Extensive basaltic eruptions throughout Earth history, covering hundreds to millions of square kilometers of Earth's surface, are all contemporaneous with periods of major warming—the larger the flow, the longer the eruption lasts, the greater the warming.

Extensive basaltic eruptions on land that cause global warming are most common in areas of continental rifting such as Iceland and the East African Rift, while explosive eruptions forming aerosols that cause global cooling are most common above subduction zones where ocean plates and continental plates are converging. The prime example is the "Ring of Fire" formed around the Pacific Ocean today, involving 452 explosive volcanoes. Motions of tectonic plates covering Earth's surface control climate in this way, causing net warming when continental rifting is most frequent and net cooling when subduction is most widespread.

Details in the geologic record document sudden global warming within just a few years followed by slow global cooling over tens of thousands of years in highly erratic sequences often as short as just a few thousand years (red line for air temperature in the figure). This interplay between basaltic lava flows and explosive, aerosol-forming volcanic eruptions explains the geologic record in considerable detail. The largest basaltic eruptions covering millions of square kilometers and erupting over tens of thousands of years, produce the greatest warming, ocean acidification, and mass extinctions. Changes in greenhouse gas concentrations, on the other hand, are unable to explain most of the details of climate change documented throughout the geologic record.

The greenhouse consensus is built on mistaken science

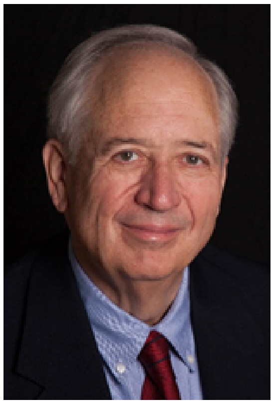
Most climate scientists have worked very hard together for decades to demonstrate consensus behind greenhouse-warming theory so that political leaders would act promptly to reduce greenhouse-gas emissions. Climate scientists have also diligently fought off politically motivated sceptics who fear new government regulations if it is shown that humans can affect climate significantly. Thus, it is easy to understand why the possibility that the science of greenhouse-warming theory could be mistaken is anathema to the scientists, while the possibility that humans manufacturing CFCs could have caused the warming from 1970 to 1998 is anathema to climate sceptics, many of whom are staunchly libertarian.

Unfortunately, most climate scientists, hiding behind "the consensus", refuse to even look at papers that question greenhouse theory. Most leading scientific journals refuse to even send papers our for review that question greenhouse theory. This is not good science. Consensus is the stuff of politics. Debate is the stuff of science. Science evolves. Science is never settled.

What is described in this short document provides, if correct, a revolution in thinking about radiation and heat in thermodynamics, climate science, and quantum physics. What are the chances that I am correct? Everything written here is based on direct observation of Nature. There are no assumptions. Interpretations of these basic observations do not depend on some theory. The closest thing to truth in science is quality observation of Nature.

Physics is about what is physically happening in the world around us. The fundamental goal of science is to understand Nature and how Nature works. We still have a lot to learn from Nature. Science is not done by popular vote. Science is not done by consensus. A major benefit of science is that, over time, it is self-correcting, but only if some scientists have minds open to evaluating new observations and new insights.

As long as climate scientists continue to ignore clear evidence that greenhouse warming theory appears to be mistaken, they are causing those who believe in the value of science for informing sound public policy to squander very large amounts of money and political capital. They are also delaying efforts to minimize ozone depletion that would reduce observed global warming. Warming due to volcanic eruptions recovers within years after the eruptions stop. Warming of the oceans due to CFC gases will continue to increase for many more decades until the ozone layer has recovered to pre-1970 levels. There is much work to be done to speed this recovery. Quality science should be leading the way.



Dr. Peter L. Ward, Dartmouth College 1965 and Columbia University 1970, chaired a White House committee and worked on a Committee for Vice President Al Gore during his 27 years as a research geophysicist and leader at the U.S. Geological Survey. He is a well-published scientist who helped develop and manage a major national research program. Ward has appeared on more than 130 television and radio shows including being featured on Good Morning America. Ward earned two national awards for educating the public about science. He founded the non-profit *Science is Never Settled* to challenge current consensus that he believes has shut down true scientific debate—the life-blood of Science.

He explains, “If Science was settled, we would still believe the Earth was flat.”

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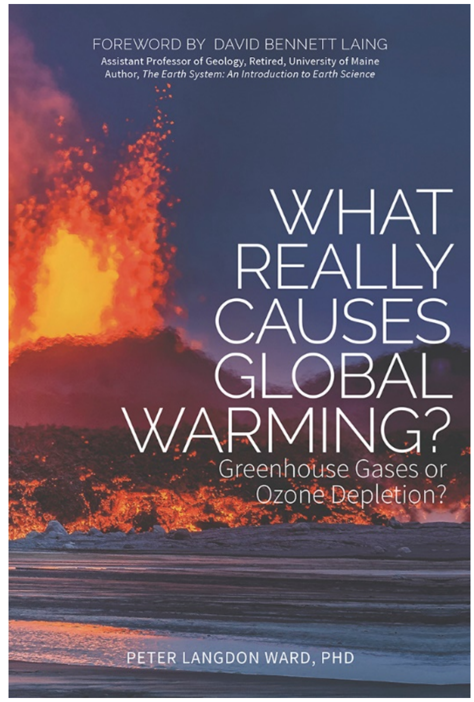

A Most Inconvenient Reality—Greenhouse Gases Cannot Physically Explain Observed Global Warming

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Key Points:

- Temperature and heat are both the result of a very broad continuum of frequencies of oscillation of all the bonds holding matter together.
- Carbon dioxide absorbs less than 16 percent of these frequencies—not constituting enough thermal energy to cause observed global warming.
- To inform sound public policy, scientists must promptly address fundamental misunderstandings about what constitutes heat and how it flows.

Abstract

Heat is what a body of matter must absorb to warm and must emit to cool. Most scientists and engineers assume that heat is some generic thing accurately quantified by a single numeric amount of thermal energy flowing per second in units of watts per square meter. While this approximation has proven useful in many cases, it fails when comparing solar ultraviolet radiation with terrestrial infrared radiation. Planck's law, an equation formulated empirically to fit extensive laboratory measurements, shows that heat is not generic. Heat consists of a very broad continuum of frequencies of oscillation of all the bonds holding matter together. Thermal energy increases with frequency of oscillation. Each frequency has an amplitude of oscillation that increases with increasing temperature of the radiating body. Ultraviolet solar radiation is nearly 50-times more energetic than infrared terrestrial radiation no matter the amount. Amount of heat, on the other hand, is a function of the temperature difference between the emitting and absorbing bodies. Matter can only be heated by absorbing radiation from a hotter body containing higher frequencies of oscillation, with higher amplitudes of oscillation at each and every frequency of oscillation. This is why Earth cannot be heated in any way by its own radiation. Furthermore, a molecule of carbon dioxide gas does not absorb heat; it merely absorbs some spectral lines of thermal energy that are the molecule's resonant frequencies of oscillation, making up less than 16% of the broad continuum of frequencies constituting the heat required to warm Earth.

Plain Language Summary

In 1822, Joseph Fourier first described a way of quantifying amounts of heat that is still widely used today. We have learned a lot since 1822, however, which was nearly a century before scientists could demonstrate that matter must consist of atoms and molecules.

In 1900, Max Planck developed a very different way of quantifying temperature and heat based on extensive laboratory measurements. Planck showed that temperature of matter is a function of a very broad spectrum or continuum of frequencies of oscillation of all the bonds that hold molecules of matter together. The higher the temperature of the matter, the higher the frequencies of oscillation and the higher amplitude of oscillation at each frequency. Furthermore, Planck showed that thermal energy is equal to the frequency of oscillation times a constant. This means that any amount of solar ultraviolet radiation is nearly 50 times more energetic that any amount of infrared radiation emitted by Earth. Solar radiation burns our skin, something no amount of infrared radiation from Earth can do. Solar radiation warms Earth, something no amount of infrared radiation from Earth can physically do. Bodies of matter cannot be warmed by their own radiation.

In 1859, John Tyndall showed in the laboratory that greenhouse gases absorb some infrared radiation emitted by Earth. Scientists today still assume that this means the temperature of air containing increasing quantities of greenhouse gases will get warmer and that this will increase global temperatures directly or by slowing the cooling of Earth. This fundamental assumption underlying greenhouse-warming theory has never been demonstrated in the laboratory and appears to be mistaken.

1. Introduction

Climate scientists have worked very hard for decades to demonstrate consensus behind greenhouse-warming theory in order to convince world leaders to make expensive and politically unpopular decisions to reduce greenhouse-gas emissions substantially and promptly before humanity faces severe consequences within the next few decades. While consensus is the stuff of politics, debate is the stuff of science. As Michael Crichton put it, "in science consensus is irrelevant. What is relevant is reproducible results. The greatest scientists in history are great precisely because they broke with the consensus."

This well-intentioned political decision by scientists to demonstrate consensus has, unfortunately, limited scientific debate about whether greenhouse-warming theory is even physically possible. It is surprising how important greenhouse-warming theory has become both politically and financially even though its veracity has never been demonstrated by an experiment in the atmosphere or in the laboratory. Experiments form a fundamental pillar of the scientific method. As Richard Feynman explains, "it doesn't matter how beautiful your theory is. It doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong." The physical sciences are all about physical reality. A physically realistic theory of global warming should be demonstrable by a physical experiment.

Greenhouse-warming theory has deep roots going back more than 200 years, although like a phoenix, it has risen from its ashes more than once because, if correct, and if the world is currently warming, it has major implications for survival of life on Earth. This would not be the first time in the history of science that such momentous possibilities might have caused some scientists to moderate their healthy scientific skepticism.

Science evolves as old ideas are constantly re-evaluated in light of new data. Carl Sagan points out how "there are many hypotheses in science which are wrong. That's perfectly all right; they're the aperture to finding out what's right. Science is a self-correcting process." But science is self-correcting only when at least one scientist is willing to question explicit and implicit assumptions used to support theories that have become widely accepted. Most scientists are busy moving forward, building on theories and assumptions that appear to have stood the test of time. Scientific revolutions happen when some laggard stumbles over a cherished assumption for good scientific reasons.

In 2006, while retired, I discovered an enigma in climate science that caused me to put aside almost everything else in my life so that I could work full time, carefully re-examining all the assumptions inherent in greenhouse-warming theory. Several details just did not make physical sense. This ultimately led me to question our fundamental understanding of temperature, heat, and the physical differences between matter and space. I appear to have identified fundamental misunderstandings about what temperature of matter physically is, what heat physically is, how heat flows, and how we should quantify that flow.

I have described elsewhere, in detail, the ozone-depletion theory of climate change, which explains observations of climate change throughout Earth history far more directly, in far greater detail, and with far greater precision than greenhouse-warming theory [*Ward*, 2016; 2017; 2018]. Most climate scientists today summarily dismiss ozone depletion as not involving enough thermal energy to affect climate. They argue that there is a greater <u>amount</u> of thermal energy in the infrared absorbed by greenhouse gases than in the ultraviolet reaching Earth when ozone is depleted. Yet we all known that ultraviolet radiation has a high-enough <u>level</u> of energy to cause sunburn, skin cancer, cataracts, and even mutations of DNA while the total amount of infrared energy in the Universe cannot cause these phenomena. This realization is when it first became clear to me that there appears to be a fundament misunderstanding about the difference between <u>level</u> of radiant energy and <u>amount</u> of radiant energy.

Ozone-depletion theory provides a clear alternative to explain observed global warming, some of which appears to have been caused by humans, but whether this new theory turns out to be verified or not is irrelevant to this paper. This paper is not about a theory. The purpose of this paper is to describe a fundamental misunderstanding in physics about the physical properties of temperature and heat in matter, air, and space and how heat flows through air and space between pieces of matter. I am not proposing some theory that greenhouse-warming theory might be mistaken. I am exposing the harsh reality that greenhouse warming theory is based on mistaken assumptions made since 1822 that are not supported by new insights into the nature of matter and thermal radiation. The results are surprising—even revolutionary. If correct, they make many things that quantum physics tries to explain both physically intuitive and deterministic, something Albert Einstein spent the last 28 years of his life searching for.

The results are also most inconvenient at a time when scientists, by forging consensus, have convinced world leaders to spend trillions of dollars to reduce greenhouse-gas emissions. This is a substantial amount of money when you realize that global gross domestic product in 2017 was only 80 trillion dollars [*CIA*, 2017]. Reducing greenhouse emissions is likely to be a complete waste of money caused by scientists refusing to even consider clear problems with greenhouse-warming theory.

Most leading climate scientists that I talk to, just cannot conceive of the possibility that something "so well-understood" as greenhouse-warming theory could have any flaws. They would rather dismiss the messenger than face this most inconvenient reality, especially at a time when science is under unprecedented attack. If we scientists want science to be valued for informing sound public policy, however, we must move promptly to evaluate emerging evidence that we appear to have convinced world leaders to waste very large amounts of money. Sticking our heads in the sands of consensus is not a viable option and could deal science a mortal blow. Time is of the essence.

2. The Physical Properties of Heat Vary with the Temperature of the Emitting Body

Heat is what a body of matter must absorb to get warmer and lose to get cooler. Heat is the spontaneous transfer of thermal energy from a warmer body of matter to a cooler body of matter by thermal conduction within matter, by thermal radiation across air and space, and by convection within a turbulent liquid, gas, or plasma. *Joseph Fourier* [1822] proposed a detailed analytical theory of heat, explaining that "heat, like gravity, penetrates every substance of the universe, its rays occupy all parts of space." He described heat as a flux, a single numeric "quantity of heat which flows at each point across a given surface" in units of watts per square meter. He pointed out that "all bodies have the property of emitting heat through their surface—the hotter they are, the more [heat] they emit." Fourier clearly thought that Sun emits the same generic thing called heat as Earth, just a whole lot more of it. He also thought of heat as additive—the greater the amount of heat absorbed, the hotter the body becomes.

Today, nearly two hundred years later, atmospheric scientists still follow Fourier's formulation despite several problems. First, in 1900, Planck developed empirically a law, which, as described below, clearly shows that the physical properties of heat change substantially with temperature of the radiating body. There is no such thing as generic heat. Second, it is well known that no amount of heat can raise the temperature of the absorbing body to be hotter than the temperature of the emitting body. For example, no amount of infrared radiation from Earth can cause sunburn. Third, it is the difference in temperature between the emitting and absorbing bodies, the temperature gradient, that has the primary influence on how much heat flows between two bodies at any instant in time. This is why curves of warming and cooling are always asymptotic, as shown by the red calculated curve in Figure 1.

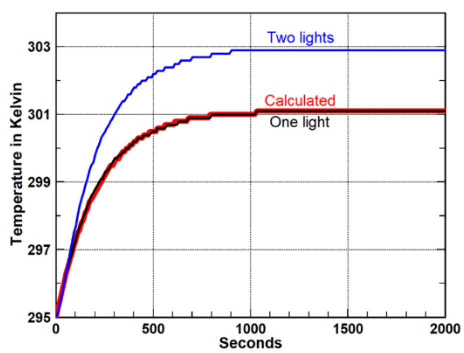
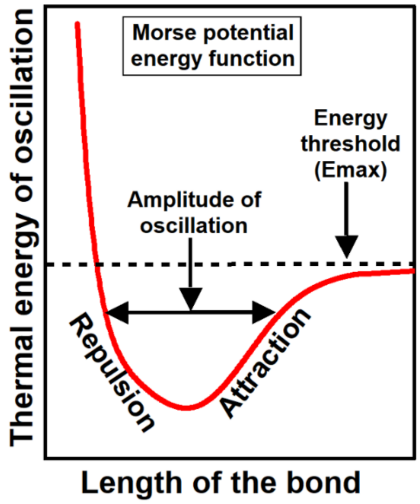


Figure 1. The rate of warming, the rate of heat flow, decreases with decreasing difference in temperature forming an asymptotic curve. The black line shows temperature increase of a black, 5-cm-square, 16-gauge metal plate caused by radiation from one 50-watt MR16 ESX picture light placed 90 cm away. The blue line shows similar warming caused by two identical lights. The redline shows the temperature calculated by adding 4.6% times the ending temperature minus the existing temperature at each 10-second interval.

Fourier's ideas appear to give reasonable answers when only small incremental changes in heat are involved and when the range of frequencies is relatively narrow. Fourier's ideas clearly fail when comparing infrared thermal radiation from Earth to the 50-times higher frequency, 50-times higher energy, ultraviolet thermal radiation from Sun.

3. The Quantum of Thermal Energy

In 1899, Max Planck concluded that "thermal radiation most probably arises from certain oscillations that take place within molecules or ions" [*Gearhart,* 2008]. Since that time, spectral physicists have observed in great detail that all bonds holding matter together are not rigid **Figure 2.** Each mode of oscillation of each



degree of freedom of each bond holding matter together oscillates as a frictionless molecule-size oscillator. As thermal energy increases, the amplitude of oscillation at each frequency of oscillation increases until the bond reaches an energy threshold Emax and comes apart.
[*Gordon et al.,* 2017]. Each mode of oscillation, of each degree of freedom, of each bond, is observed to oscillate between electromagnetic forces repelling like charges and different electromagnetic forces attracting unlike charges. These molecule-size oscillators, with lengths on the order of 10^{-10} meters, are often visualized as behaving according to the Morse potential energy function [*Morse*, 1929] or now more precisely by the Morse/Long-range potential energy function [*Le Roy et al.,* 2009]. As shown in Figure 2, when thermal energy increases, the amplitude of oscillation increases until the bond comes apart at Emax.

Electromagnetic forces are frictionless. Therefore, each oscillator has an energy of oscillation (E) that is simply equal its frequency of oscillation (v, the Greek letter nu) times a scale factor (h): E=hv, an equation first postulated by *Planck* [1900]. The important concept here is that energy of oscillation (E) is the same physical thing as frequency of oscillation (v). In other words, frequency of oscillation (ν) is physically the energy of oscillation (E). To express energy in joules, we multiply frequency of oscillation by h, a scale factor known as the Planck constant—the number of joules of oscillatory energy "contained" in a frequency of one cycle per second—the slope of the line of energy as a function of frequency passing through the origin. In this way, the Planck constant can be estimated easily using light-emitting diodes in a high school physics laboratory [*Rute and Sérgio*, 2014].

In physics, we typically treat energy as a subtle concept [*Coopersmith*, 2010]. We think of heat, for example, as a flux of energy per second, but this avoids having to specify the physical nature of the energy that constitutes heat. E=h*ν*, on the other hand, says simply that the energy of a single, frictionless oscillator is physically the same thing as its frequency of oscillation. This can be confusing at first because we are not used to thinking of frequency or energy as physical things. They are not material things, but they are things that we know are physically happening around us, even though we cannot see them.

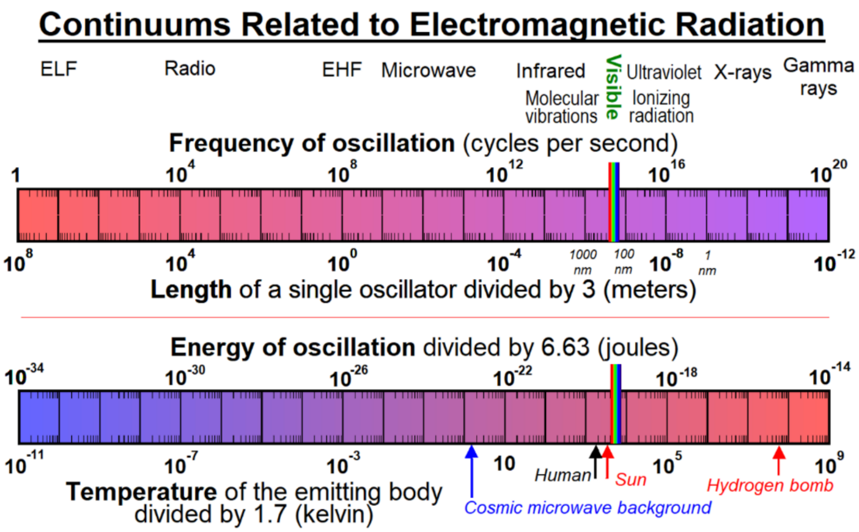


Figure 3. Electromagnetic radiation consists of a continuum of frequencies of oscillation. The effective length of an individual oscillator, formerly thought of as wavelength in terms of wave frequency, equals, as a first approximation, the velocity of light (3×10^{8} meters per second) divided by frequency of oscillation. The energy of oscillation is equal to frequency of oscillation times the Planck constant (6.63×10^{-34} joules per cycle per second). The resulting temperature of matter is equal to the frequency of oscillation times the inverse of the Wien displacement constant (1.7×10^{11} degrees Kelvin per cycle per second).

The tricky part of this is that frequency of oscillation contained in electromagnetic radiation transporting heat is well-observed to be a continuum (Figure 3). This continuum is a very broad range of values that coexist and do not interact in air and space. The continuum extends from extremely low frequency radio signals oscillating at cycles per second (10^{0}), to infrared radiation from Earth whose maximum amplitudes of oscillation (Figure 4) peak around 30 trillion (3×10^{13}) cycles per second, to visible light oscillating at frequencies around 500 trillion (5×10^{14}) cycles per second, and ultimately to gamma rays oscillating at frequencies greater than 100 quintillion (10^{20}) cycles per second.

Since frequency (*ν*) is a continuum, then energy (E), which equals the Planck constant (h) times a continuum, must also be a continuum. Radiant energy, therefore, is not quantized, although the physical source of radiant energy, these molecule-size oscillators, are physically quantized. For each and every frequency in this continuum, down to some molecular granularity, there is a discrete, molecule-size oscillator on the surface of the radiating body transmitting that frequency just as a radio transmitter transmits its frequency by motion of charge. This means that the smallest chunk into which electromagnetic radiation can be subdivided is a physical, molecule-size oscillator—in effect the atom of electromagnetic radiation or the quantum of electromagnetic radiation. Each oscillator is oscillating at a specific frequency of oscillation, which is a specific energy of oscillation. This energy, E=h*ν*, can take on any numeric value throughout the continuum.

This is not our current understanding. E=h*ν* is well-known as the Planck-Einstein relation and is integral to quantum physics where E is thought to be the energy of a photon based on Einstein's interpretation of the photoelectric effect [*Einstein*, 1905]. A photon is thought to be a type of elementary particle, the quantum of electromagnetic radiation. Energy in electromagnetic radiation is thought to be expressed only in terms of integral numbers of photons: E=nh*ν*, where n must be an integer. Quantum mechanics is based on the concept that it is the energy itself that is quantized. But radiant energy is well-observed, as shown in Figure 3, to be a continuum. Therefore, radiant electromagnetic thermal energy is not quantized. What is physically quantized in Nature is the individual, molecule-size, frictionless oscillators for each of the modes of oscillation of each of the degrees of freedom of each of the bonds holding matter together.

Einstein [1905] proposed the "light quantum," E=h*v*, to explain the photoelectric effect discovered by *Hertz* [1887], who found that when you shine a light on an unoxidized metal surface, electrons flow only when the color of light is above some minimum frequency, above some minimum level of energy (E=h*v*). Above that level, the higher the intensity of the light, the more electrons flow. Below that level, no electrons flow no matter the intensity. Thus E=h*v* is the minimum level of energy, the minimum frequency of light, that can break the bonds holding an electron on the unoxidized surface of a metal—essentially Emax in Figure 2. We see the same effect with dissociation of molecules such as oxygen (O_2) where frequency of oscillation must be within the ultraviolet-C spectrum at a value of around 1237 terahertz (traditionally thought of as a wavelength of 242.4 nanometers), an energy of 5.1 electron volts.

4. Planck's Law and the Continuum of Frequency of Oscillation

In 1900, Planck formulated, by trial and error, an equation successfully describing mathematically the observed physical properties of thermal radiation (Figure 4) [*Gearhart*, 2008; *Planck*, 1900]. Thermal radiation is defined as the radiation emitted spontaneously by a body of matter resulting from its temperature. The body is assumed to be black, meaning its surface is a perfect absorber and emitter of radiation, and to be in a state of thermal equilibrium, meaning that the temperature is the same at every point throughout the body such that heat is no longer flowing within the body. This equation, which became known as Planck's law, accurately fit related laboratory data [*Ångström*, 1892; *Langley*, 1888; *Lummer and Pringsheim*, 1899; *Paschen*, 1899; *Rubens and Aschkinass*, 1898] and still fits extensive data available today.

Planck [1900] postulated that there must exist "discrete energy elements", E=h*v*, the energy of oscillation of what he thought of as a "resonator". He introduced h*v* as the main term for energy in his equation (Figure 4A) and multiplied it by two times the frequency of oscillation squared divided by the velocity of light squared ($2v^2/c^2$) to make the units watts per square meter.

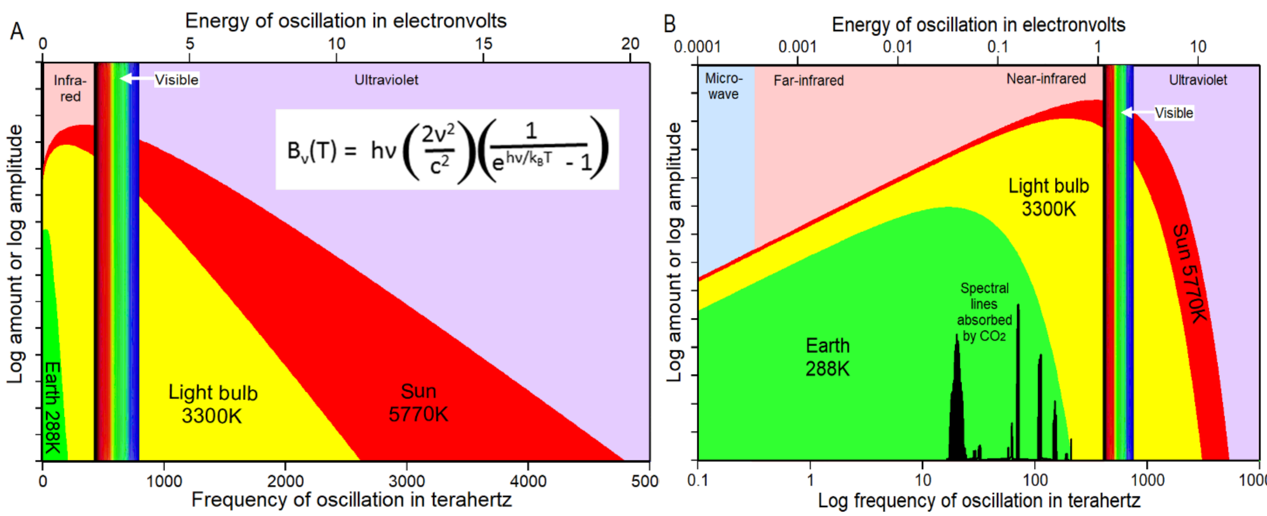


Figure 4. Planck's law plotted with linear x-axis on the left and logarithmic x-axis on the right. The vertical black lines on the right are the frequencies of spectral lines of radiation absorbed by CO_2.

Planck also uses h*v* in the exponential term (hv/k_BT) (Figure 4A), the ratio of joules of oscillatory energy (h*v*) at the molecular level to joules of energy as a function of absolute temperature (k_BT), where k_B is the Boltzmann constant, the number of joules per unit absolute temperature (T).

Planck's law (Figure 4A) calculates, for a body of matter at a specific temperature, the amount of radiant energy at each frequency. Planck's law shows that temperature in matter is the result of a very broad continuum of frequencies of oscillation with several key physical properties. The hotter the body of matter, 1) the broader the continuum of radiated frequencies of oscillation with significant amount, 2) the greater the amount at each and every frequency of oscillation, especially at higher frequencies, and 3) the higher the frequency of oscillation with the greatest amount. No matter how a body of matter is heated, when that body reaches thermal equilibrium, the distribution of frequencies and amounts observed to be emitted are observed to be those described by Planck's law. For example, a body of matter "possesses" a temperature of 3300K only if it contains every single one of the frequencies of oscillation plotted in yellow in Figure 4 and has the amounts (amplitudes) shown in yellow. If the amounts are less, the temperature is lower. If the amounts are more, the temperature is higher. Note that the basic shape of the Planck curve is always the same for thermal radiation and that curves for different temperatures do not intersect except at absolute zero.

Most importantly, Planck's law shows clearly that heat is not a single numeric value of watts per square meter as assumed by Fourier and most scientists today. Heat is a continuum, an infinite series of numeric values. A physical description of the heat that must be absorbed by Earth to become as warm as 3300K is shaded yellow in Figure 4.

We can think of a continuum mathematically as a Fourier series with commas replacing the plus signs and with the number of terms approaching infinity. In a Fourier series, the plus signs implement the principle of superposition, adding up all the single-frequency sinusoidal waveforms to find the solution for a general waveform. This addition is enabled by the bonds holding matter together. In air and space, however, there is no matter and there are no bonds. There is no physical way for the frequencies of oscillation to be added together or to interact with each other in any way. It makes no physical sense, for example, to add red light to blue light. You do not get ultraviolet light. You simply get some red light coexisting with some blue light.

5. Amount of Radiation Should Be Amplitude of Oscillation

The data fit by Planck's law were measured by passing light through a prism, which spreads the spectrum out spatially into a rainbow, and then placing a sensor at different angles within each narrow band of color. Infrared radiation does not possess enough energy to penetrate glass. The prism, in that case, was made of halite (rock salt) [*Langley*,1886]. The sensor was typically a thermopile or resistor that changed a very small electrical current, measured in watts, as a function of temperature. Scientists were measuring the thermal effect of a narrow band of radiation on a small piece of matter within their sensor. They thought of this as spectral radiance in units of watts per steradian per meter squared per cycle per second, plotting it on the y-axis as a function of wavelength on the x-axis.

Wavelength, however, and wave frequency (the velocity of light divided by wavelength) both assume Maxwell's wave-theory of light, which cannot apply in air and space as described below. Also described below is how light can display wave-like features such as interference and reflection, but only when in the immediate presence of matter. What scientists were physically measuring was the intensity or brightness of the radiation within a narrow band of frequencies of oscillation (v). Energy of light (E) is equal to a constant (h) times frequency (v). A small amount of blue light has the same level of energy as a large amount of blue light, while blue light has a higher level of energy than red light. Thus, energy (E) should be plotted on an alternative x-axis shown at the top of the graphs in Figure 4, not on the y-axis.

We all observe that light has two physical properties: color, which is frequency of oscillation, and intensity or brightness, which is amplitude of oscillation. What scientists were measuring physically was a proxy for what we perceive as intensity or brightness, resulting from amplitude of oscillation. Measuring amplitude of oscillation in picometers (10^{-12} meters) was not easy in 1900 and still takes some effort. Thinking of the y-axis as amplitude of oscillation does not change the basic shape of a Planck curve, but a scale factor replacing $2h/c^2$ for the y-axis needs to be calibrated in the laboratory in units of meters per frequency of oscillation cubed. This constant is, most likely, the slope, on a log-log plot (Figure 4B) of a Planck curve at low frequencies. In the meantime, I only show orders of magnitude without specific values on the y-axes in Figure 4.

Planck's law calculates, at a given absolute temperature, this normal amplitude of oscillation as a function of frequency of oscillation. All frequencies of oscillation coexist at all locations and at all times throughout the universe. What varies with increasing temperature of the emitting body and decreasing distance squared is amplitude of oscillation at each frequency of oscillation, ranging from imperceptible to dominant.

6. Thermal Radiation Propagates by Resonance

Electromagnetic forces are frictionless. Therefore, each of these tiny, molecule-size oscillators is frictionless. The only known way to increase or decrease the amplitude of oscillation of a frictionless oscillator is by sympathetic resonance. Resonance is a physical phenomenon where one oscillating system "shares" its amplitude of oscillation with another system oscillating at nearly the same frequency. Resonance is what Einstein referred to as "spooky action at a distance" [*Born et al.*, 1971]. Resonance is the observed physical process that quantum physicists seek to explain as quantum entanglement.

Perhaps the simplest example of electromagnetic resonance is how you hear your favorite radio station. The radio station transmits at a specific frequency of oscillation. Transmission is thought to be by motion of charge on the surface of its antenna. You tune your radio receiver to resonate at that frequency, picking the amplitude of oscillation of just that frequency of oscillation out of the broad continuum of all frequencies. This is how signals from hundreds of radio stations, cellphones, WIFI signals, etc. all coexist in the air around us. Amplitude of oscillation is observed to decrease with the inverse square of distance. Your radio, therefore, usually receives the clearest signals from local stations.

Through resonance, two oscillators typically average their amplitudes of oscillation. The oscillator with the greater amplitude "gives up" one-half of the difference in amplitude while the oscillator with the lesser amplitude "absorbs" one-half of the difference in amplitude. Thus amplitude "flows" from higher amplitude to lower amplitude at the same frequency, which, from Planck's law (Figure 4), means from higher temperature to lower temperature. Heat "flows" spontaneously when resonance occurs simultaneously across each and every frequency in the continuum.

Resonance also explains how Planck curves maintain their shape. The amount of amplitude transferred at each frequency is one half of the difference in amplitude at that frequency. Through resonance, amplitudes of oscillation are not physically added together. They are not additive as currently assumed. Rather, they are averaged together at the molecular scale. We could say they are "averative", a word coined here to clarify this distinction. At the macroscopic scale, values of temperature resulting from molecule-size oscillators are also averative. If you take two bodies of matter that are identical in every way except for temperature and connect them together thermally, the resulting temperature, at thermal equilibrium, becomes the average of the initial two temperatures. The greater the difference in temperature, the greater the flux in amplitude and the greater the flux for each particular frequency component of heat.

This averaging is the reason why warming and cooling curves are asymptotic as demonstrated by the red calculated curve in Figure 1. Temperature rises quickly at first when the temperature difference is greatest. Then temperature rises much more slowly, approaching its warmest temperature asymptotically.

By resonance, amplitude flows only from one discrete physical oscillator on the emitting surface to one discrete physical oscillator on the absorbing surface. Conduction of heat via resonance within matter is enhanced by close proximity of independent oscillators. In air and space, resonance is enabled via line-of-sight by electromagnetic radiation, which is transmitted by molecule-scale motion of charge at very high frequencies of oscillation. Frequency of oscillation of radiation is well observed to travel through air and space without any change, even over galactic distances, except for Doppler effects.

Amplitude of oscillation, on the other hand, is well observed to decrease with the square of the distance travelled. This decrease can be understood in terms of the apparent density of molecule-size oscillators on the surface of the near and distant bodies. Over short distances, there is a one-to-one correspondence between oscillators. As distance increases, the distant object looks smaller and smaller. Fewer and fewer molecules on the distant surface are available to resonate with the one molecule on the near surface. Thus, the amplitude transferred by resonance must then be shared by conduction with more and more similar oscillators on the distant surface as they reach thermal equilibrium. In this way, the rate of amplitude transfer slows with the square of increasing distance.

7. Resonance Is All Around Us

We perceive visible light from 430 to 770 terahertz (trillion cycles per second, THz) because these are the resonant frequencies of the cells in the cones of our eyes. Three types of cone cells (L, M, and S) are most responsive or sensitive to three different bands of color shown by the lines in Figure 5 [*Stockman et al.*, 1993]. Each triad of cone cells transmits simultaneously three different amplitudes of oscillation encoded in nerve impulses to our brain for each pixel that we see. The size of a pixel is determined by the minimum diameter of a cone cell, which is about 500 nanometers (5×10^{-7} meters). Our brain, by reassembling the relative intensities of these three signals, can distinguish approximately 10 million different shades of color. This process is the inverse of the process by which a computer sends amplitudes of oscillation of primary red, green, and blue colors (RGB) encoded in 32 bits to a pixel of a computer monitor that can then display more than 16.7 million different shades of color.

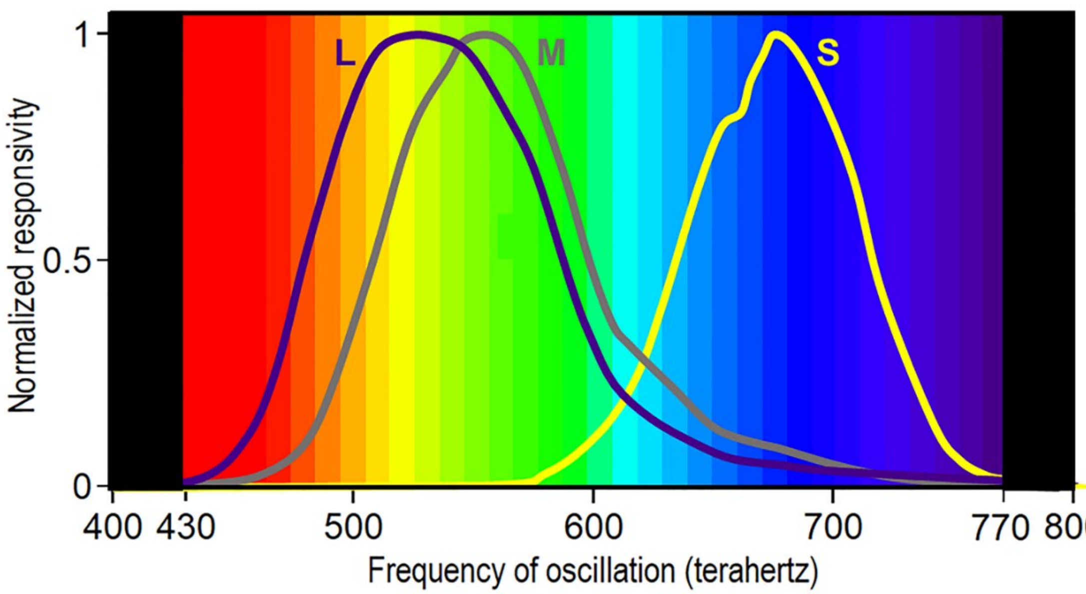


Figure 5. Human eyes are generally sensitive to frequencies of 430 to 770 THz as shown by the normalized responsivity of L, M, and S cones (solid lines).

Matter illuminated by electromagnetic radiation containing no frequencies between about 430 THz and 770 THz appears black because these frequencies cannot be detected by human eyes (Figure 5). Thus, black is not a specific frequency; black is what we perceive when there is no visible color. White, on the other hand, is what we perceive when all visible colors simultaneously have substantial amplitudes of oscillation. The more equal the amplitudes of oscillation, the whiter the white.

During resonance, amplitude of oscillation normally increases and decreases over a band of frequencies as shown by the curves in Figure 5, depending on the oscillator's physical structure and its interaction with adjoining oscillators. The breadth of the band is related to the damping of the oscillator often quantified as the quality factor, or Q-factor [*Hecht*, 2016]. It is the slopes of these curves that provide the differences that the brain can use to distinguish about 10 million colors. Scientists are beginning to realize, similarly, that a small number of sensor types involving resonance may be what enables animals to recognize a very wide range of smells and tastes [*Burr*, 2004; *Piesse*, 2015]. The fact that smells and tastes are much more intense at higher temperatures, higher amplitudes of oscillation, suggests that frequency of oscillation and resonance may play the dominant role. In fact, all five senses may be based on resonance.

Thinking in terms of resonance provides a whole new way to understand the flow of heat. For example, when there are clouds in the sky, the bonds holding molecules of water together in the cloud resonate with bonds on Earth's surface. Since the clouds are warmer than deep space, the difference in amplitude of oscillation between Earth and the cloud is smaller than the difference between Earth and deep space. Therefore, the flow of amplitude from Earth to the cloud decreases (Figure 1), making cloudy nights warmer than clear nights.

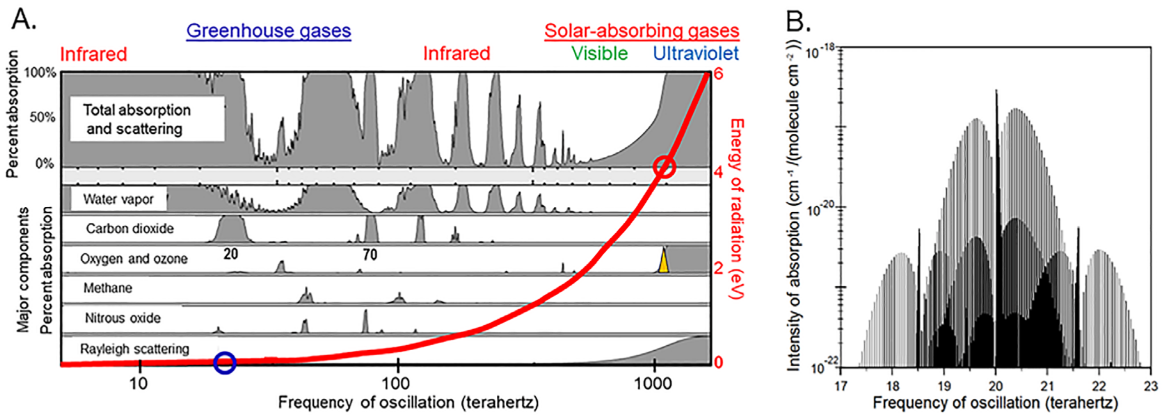


Figure 6. Spectral regions absorbed by greenhouse gases are shaded gray. Absorption is along spectral lines too close to see in the shaded areas on the left. Individual spectral lines are plotted on the right for the broad band of absorption for CO_2 at 20 terahertz labeled on the left. The red line shows the energy of radiation: $E=h\nu$.

8. Greenhouse Gases Merely Absorb Spectral Lines of Energy

Spectral physicists document in detail that greenhouse gases merely absorb infrared radiation within narrow bands of frequencies shown by the vertical black lines in Figure 4B and shaded areas in Figure 6A [*Gordon et al.*, 2017]. Furthermore, within these bands, they only absorb narrow spectral lines of energy that are the resonant frequencies of oscillation of the bonds holding all the molecules together (Figure 6B). *Ångström* [1900] concluded that "no more than about 16 percent of earth's radiation can be absorbed by atmospheric carbon dioxide," convincing most physicists at the time that greenhouse-warming theory was not physically possible. Heat radiated by Earth consists of 100% of the frequencies shown in green in Figure 4. If you only absorb 16% of these frequencies, you do not absorb heat in the same way that if you have 16% of a person, you do not have a person. No matter how you propose spectral lines of energy absorbed might cause warming of air, greenhouse gases simply do not absorb heat, they do not absorb enough thermal energy to have much effect on temperature. In the vernacular, they simply do not have enough skin in the game.

Temperature is proportional to how fast atoms are moving relative to each other [*Grossman*, 2014]. The higher the velocity of the atoms, the higher the temperature. In a gas, where each atom or molecule is free to move in any direction, temperature is proportional to the average kinetic energy of translation of all atoms and molecules ($E=\frac{1}{2}mv^2$). In condensed matter, i.e. solids and liquids, where the atoms are all interconnected by chemical bonds into molecules and molecules are all held together by a variety of intramolecular forces, temperature is proportional to the kinetic energy of oscillation of all of these bonds (Figure 4).

For a greenhouse gas absorbing terrestrial infrared energy to cause warming of air, one must assume that the kinetic energy of oscillation absorbed into the bonds is converted to kinetic energy of translation during myriad collisions. This conversion has never been quantified in the laboratory but cannot be very efficient. Furthermore, carbon dioxide, for example, makes up only 0.04% of the gas molecules in air and thus would have to share their kinetic energy with the other 99.96% of the molecules. In addition, by Planck's law (Figure 4), radiation from Earth does not contain high enough amplitudes of oscillation at all frequencies of oscillation to warm Earth. A body of matter cannot physically be warmed by its own radiation.

It has been assumed ever since *Tyndall* [1859] first observed that greenhouse gases absorb infrared energy, that, therefore, they warm air. This assumption has never been verified by experiment and appears to be physically impossible.

The greatest warming of air observed in Earth's atmosphere is daily in the stratosphere where solar radiation maintains the temperature of the stratopause approximately 60 K warmer than the temperature of the tropopause. This warming is caused by solar ultraviolet-C radiation dissociating oxygen and other gas species and solar ultraviolet-B dissociating ozone and other gas species. Upon dissociation, the pieces of the gas molecule fly apart at high velocity, converting all the energy stored in the bond directly into air temperature. Dissociation of oxygen and ozone occur in the endless Chapman cycle until all ultraviolet-C and most ultraviolet-B is absorbed above the tropopause. Dissociation and ionization are the only ways known that gases absorbing radiant energy can become warmed.

A common claim is that Earth would be 33 K colder were it not for greenhouse gases. These back-of-the-envelope calculations do not include the effect of the stratosphere. We observe clearly that the stratosphere forms an electric blanket around Earth. Electric in the sense that the energy to warm the blanket comes from a distant source, Sun, not from the body under the blanket, Earth. It is the stratosphere that is observed to keep Earth warm—not greenhouse gases.

9. Light Cannot Physically Travel as Waves, Nor as Particles

Maxwell [1865] developed a series of equations that seemed to describe accurately waves of light traveling through space at the speed of light via electric and magnetic fields. Yet Hooke, Fresnel, and others recognized that waves are the deformation of matter and there is no matter in space to deform. They proposed, therefore, that waves in space must travel in a luminiferous aether, which was thought to be some invisible form of matter. Numerous physicists in the 19th century tried to demonstrate the presence of a luminiferous aether, but *Michelson and Morley* [1887] showed, in a definitive experiment accepted by most physicists, that such an aether does not exist.

There are other issues with light waves. For example, light that we see travels from point to point with all the energy traveling along what we think of as rays, whereas waves would smear the energy out over space, blurring our vision. Furthermore, the higher the wave-frequency of seismic waves, the greater the attenuation with distance. Light has frequencies 10^{14} times higher than the frequencies of seismic waves. There is no material stiff enough to allow such high frequencies to propagate as waves.

Yet to this day, most physicists are convinced that light travels as waves or as wave-particle duality. They rationalize that electromagnetic waves must be different, in some way, from waves in matter. The difference is in what we mean by frequency. When I say light travels as frequency, people always respond "yes but frequency equals the velocity of light divided by wavelength." They are talking about wave frequency. I am talking about frequency of oscillation—something totally different. Wave frequency travels with some velocity and the dominant frequencies typically decrease in frequency with distance. Frequency of oscillation is well observed not to change with distance, even over galactic distances.

Light does appear to have a velocity that Maxwell concluded is equal to one divided by the square root of the product of two constants: the vacuum permittivity, which is the resistance to forming an electric field, times the magnetic permeability, which is the ability to form a magnetic field [*Maxwell*, 1873]. What we think of as velocity of light may simply be the very short but finite interval of time that it takes for what we think of as an electric field to induce a magnetic field to begin to induce an electric field again. It is this very rapid interaction that appears to enable resonance.

Newton [1704] argued that light must be particles because rays of light are very straight. *Einstein* [1905] showed that the photoelectric effect, which cannot be explained by Maxwell's wave equations [*Maxwell*, 1873], can be explained by assuming the energy of light is quantized as $E=h\nu$, ultimately thought of as the energy of a photon, a particle of light. While Einstein did not express it this way, it seemed logical that an incoming particle would knock an electron loose much like a billiard ball. To this day, no one has explained physically, in detail, how a photon interacts with a gas molecule nor how a shower of photons interacts with a gas molecule to transfer the spectral lines of energy observed in Figure 6B. The clearest problem with the photon concept is, as explained above, that frequency and, therefore, energy of electromagnetic radiation are continua. If $E=h\nu$, then energy is not quantized. It is the source of energy that is quantized—the myriad of tiny physical oscillators. Light, other electromagnetic radiation, and heat all appear to travel by resonance.

10. But What About the Wave-Like Features of Light?

For most physicists, the strongest argument that light travels as waves is that light displays properties such as interference, reflection, refraction, diffraction, dispersion, and birefringence traditionally explained by wave-theory. These properties, however, are not observed in space. They are observed only when light impinges on matter—is in the immediate vicinity of matter. It is the bonds holding the surface of matter together that enable the interaction of frequencies.

Every mode of oscillation, of each degree of freedom, of each bond on the surface of any object that we see is transmitting a frequency of oscillation based on the temperature of the object. In the temperature range in which humans live, all frequencies of oscillation with significant amplitude of oscillation are in the infrared and microwave frequency bands (Figure 4). When visible light containing much higher frequencies of oscillation shines on matter, most frequencies of oscillation are absorbed into the matter but some cause molecules on the surface to resonate at specific frequencies that constitute the color of the surface. This color may be determined by pigments, dyes, or structural coloration. These frequencies then resonate with the cones in our eyes causing us to see that color.

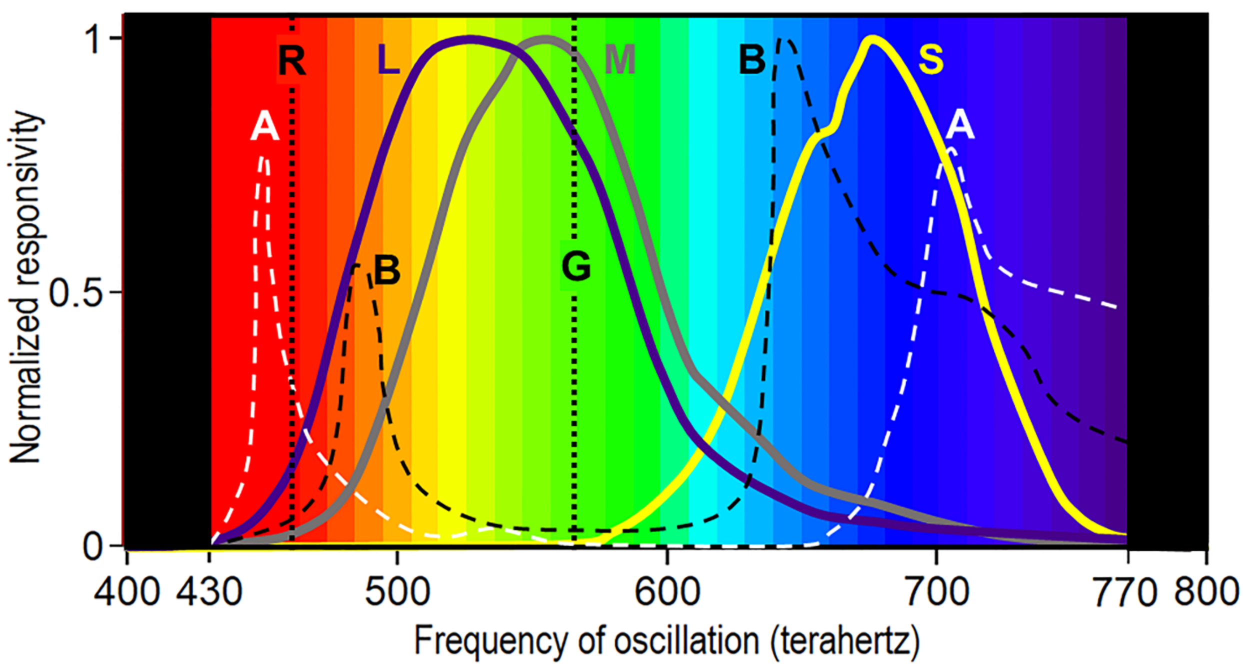


Figure 7. Human eyes are generally sensitive to frequencies of 430 to 770 THz as shown by the normalized responsivity of L, M, and S cones (solid lines). The dashed lines show the responsivity of chlorophyll-A and chlorophyll-B. The dotted lines show the frequencies typical of red and green laser pointers. Note how much more sensitive the human eye is to green lasers than to red lasers.

Figure 7 shows the response of human eyes to color shown in Figure 5 with the addition of the responsivity of chlorophyll-A and chlorophyll-B, which are green pigments found in cyanobacteria and the chloroplasts of algae and plants. Reds and blues are strongly absorbed into the chlorophyll providing the energy for plants to grow, while greens oscillate on the surface, transmitting the green color where it can resonate with the cones in our eyes. Thus, incoming light is not reflected, it is absorbed through resonance by pigments or dyes and selectively retransmitted as color.

Classical laws of reflection, refraction, and interference rely on the Huygens-Fresnel principle, developed in 1678 and 1818, which assumes that every point to which light reaches becomes the source of a spherical wave of light. This is similar to retransmission discussed above except retransmission occurs only on the surface of matter, not at every point in space and each bond oscillator has an orientation, a correction added to the Huygens-Fresnel principle by *Miller* [1991].

There are many details to work out, but it appears that the wave-like properties of light may be more precisely explained by retransmission than by classical wave theory.

11. Some Implications

Recognizing that temperature and heat are the result of a broad continuum of frequencies of oscillation of all the bonds holding matter together, that thermal energy is not quantized but its molecule-size sources are, and that amplitude of oscillation at each discrete frequency of oscillation travels by resonance, leads to several important insights.

The bonds holding matter together contain substantial thermal oscillatory energy. The hotter the matter, the higher the frequencies of oscillation, the greater the energy of oscillation, the higher the amplitudes of oscillation, and the higher the frequencies with the greatest amplitudes of oscillation. As the temperature of matter approaches absolute zero, the energies, frequencies and amplitudes of oscillation all approach zero. Frequency and therefore energy also increase with decreasing length of a bond. Thus, atomic bonds contain much greater oscillatory energies than molecular bonds. Molecular bond energy flows as heat by resonance and is converted directly into air temperature when the bonds come apart by dissociation. One way to look at Einstein's famous equation $E=mc^2$ is that it says that matter physically consists of a very large number of bonds that contain very large amounts of oscillatory energy. The more matter, the more bonds, the more energy.

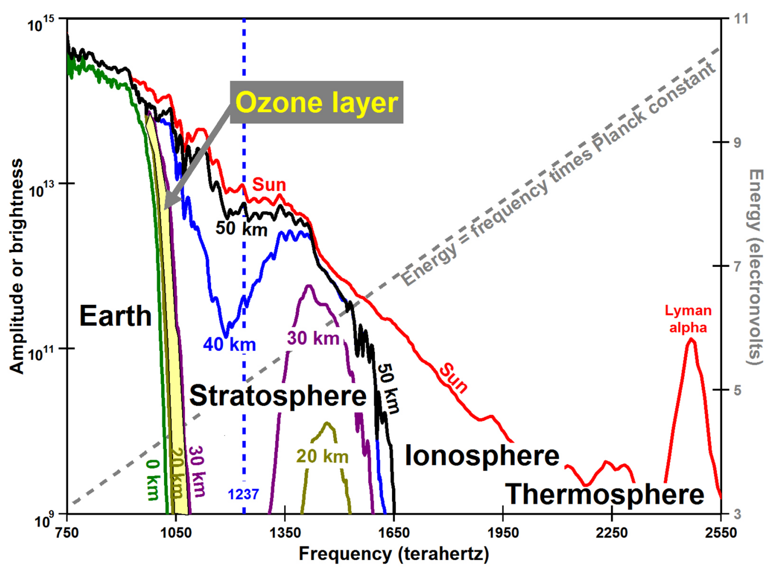


Figure 8. The highest frequency, highest energy solar radiation is absorbed high up in the atmosphere. The red line shows the amplitude of solar radiant energy received at the top of Earth's atmosphere. The other solid lines show, in effect, how much of that solar radiation has been absorbed at different altitudes labeled. The dashed blue line shows the frequency (1237 THz) where oxygen is dissociated. The dashed gray line show the energy of that frequency of radiation.

Electromagnetic radiation, light, is thought to travel through an electromagnetic field as waves or particles at the speed of light. A field is thought to be a physical quantity, either a number or a tensor, that can be measured at each point in space and time, mapping out a distribution in air or space—what *Feynman et al.* [1963] called a "condition in space". Thinking in terms of resonance, we can now understand that an electromagnetic field is nothing more than a three-dimensional map of what an appropriate sensor would measure if it were placed at that point and resonated with the source of the radiation. Thus, the only physical thing that needs to exist in a field and in radiation is the ability to foster resonance. We think of an electric field as the result of stationary charge and a magnetic field as the result of moving, oscillating, charge. Resonance only occurs when the frequency of oscillation in the emitting oscillator is very close to the frequency of oscillation in the absorbing oscillator and when there is a difference in amplitude of oscillation. Precisely how resonance occurs over very short to galactic distances, how resonance has a time delay with distance so that it appears to travel at the speed of light, and how resonance changes with time are all things we should be able to observe and quantify in the laboratory.

The Morse potential energy function posits that a molecule is dissociated when the thermal energy of oscillation reaches an energy threshold in an asymptotic manner (Emax in Figure 2). There is another possibility. Figure 8 shows the altitude above which solar radiation of different frequencies is absorbed in Earth's atmosphere [*DeMore et al.*, 1997]. The blue dashed line at a frequency of 1237 THz is the frequency, the level of energy observed to cause dissociation of molecular oxygen into two atoms of oxygen. Note that absorption in the stratosphere at altitudes from 20 to 50 km is nearly symmetric about this frequency. Thus, it is not all frequencies above 1237 THz that cause dissociation, it is frequencies in the vicinity of 1237 THz. This suggests that the bond resonates in the vicinity of 1237 THz, suddenly causing larger amplitudes of oscillation than the asymptotic manner posited by the Morse potential energy function.

It is the oscillation of all the bonds holding matter together that enable resonance. We think of the oscillation as being driven by the forces of repulsion of like charges and the forces of attraction of opposite charges. The question is, what is charge, or, more directly, what enables bond oscillation?

12. Conclusions

Heat is what a body of matter must absorb to increase its temperature and must emit to decrease its temperature. Both temperature of matter and heat are the result of a very broad continuum of frequencies of oscillation of all the bonds holding matter together as described by Planck's law. A body of matter at a given temperature is observed to radiate all of the frequencies of oscillation at the amplitudes of oscillation described by Planck's law. Heat is the continuum of amplitudes and frequencies described by the difference in two Planck curves for the starting and ending temperature.

Greenhouse gases absorb only some spectral lines of radiation that are the resonant frequencies of the bonds holding the molecules together. They do not absorb heat. Carbon dioxide, for example, absorbs less than 16 percent of the frequencies of oscillation radiated by Earth. What carbon dioxide absorbs cannot physically make air much warmer. Furthermore, radiation from a body of matter cannot in any way warm that body as shown by Planck's law.

The problem with greenhouse-warming theory is that, contrary to current thinking, heat cannot be described adequately by a single number of watts per square meter, and heat is not additive. Temperature and heat are averative. If you take two bodies of matter that are identical in every way except for temperature and connect them together thermally, the resulting temperature, at thermal equilibrium, becomes the average of the initial two temperatures. Heat flows by resonance where two discrete oscillators at nearly the same frequency of oscillation average amplitudes of oscillation. The greater the difference in amplitude, which by Planck's law means the greater the difference in temperature, the greater the amount of heat that flows per unit time.

These misunderstandings regarding temperature and heat were first quantified by Fourier in 1822 and form the foundation of greenhouse-warming theory. It is now clear that greenhouse-warming theory is not physically possible and that observed global warming is explained far more directly, in far greater detail, and with far greater precision by observed ozone depletion caused by humans and by volcanic eruptions.

Scientists, in their well-meaning drive to forge consensus around greenhouse-warming theory in order to convince political leaders to spend trillions of dollars to reduce greenhouse-gas emissions, appear to have made a mistake. It is extremely important to the world and to good science that these scientists promptly address such fundamental misunderstandings and evaluate the best route forward. Time is of the essence.

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Rejection letter from JGR Atmospheres

July 7, 2018
Dear Dr. Ward:

Thank you for submitting your manuscript to Journal of Geophysical Research - Atmospheres. We have reviewed your manuscript within our editorial board. While I am delighted to read the background materials in your paper and I appreciate your good intention to promote rigorous science by presenting different viewpoints, I have decided to decline your paper for publication in JGR-Atmospheres. Our journal only publishes original research, but much of the content in your paper is popular science. For the discussion on the role of greenhouse gases, you simply stated what you believed. You did not substantiate your arguments with rigorous quantitative calculations or analysis of measurements. This is not enough for our journal. For example, you stated in Lines 443-445 "No matter how you propose spectral lines of energy absorbed might cause warming of air, greenhouse gases simply do not absorb heat, they do not absorb enough thermal energy to have much effect on temperature". This statement is too qualitative for our journal. Similar statements are in the paragraph starting from Line 454. These statements are in the main section of your paper from which your conclusion was drawn.

I am sorry that I cannot be more encouraging at this time. Thank you for your interest in JGR-Atmospheres.

Sincerely,

Minghua Zhang
Editor-in-Chief
Journal of Geophysical Research – Atmospheres

While I sent a lengthy reply, which was ignored, to dismiss this paper as unoriginal, "popular science" and lacking "rigorous quantitative calculations" is absurd. These comments show that this editor did not read, or at least did not understand this paper and is dismissing it simply because I question the veracity of greenhouse-warming theory. I am the only scientist is the world, since Knut Angstrom in 1900, who has tried to understand the actual physics of greenhouse-warming theory—how physically warming occurs. I describe in this paper and in referenced papers why:

1. Heat, which is what a body of matter must absorb to get hotter, is a continuum of frequencies of oscillation of all the bonds holding matter together as shown by Planck in 1900, not an amount in watts per square meter as currently assumed.
2. That heat travels as a spectrum of frequencies and amplitudes of oscillation by resonance, not as waves, particles, or wave/particle duality.
3. That Earth can only be warmed by absorbing radiation from a warmer body of matter—one form of the second law of thermodynamics.

4. That solar radiation has very different physical properties than radiation from Earth. Solar radiation includes visible light and ultraviolet radiation.
5. That solar ultraviolet radiation burns your skin, causes skin cancer, causes cataracts, and causes mutations while no amount of terrestrial radiation over any period of time can cause these thermal effects.
6. That terrestrial radiation does not contain high enough amplitudes of oscillation at all frequencies of oscillation to warm Earth.
7. That greenhouse gases do not absorb enough heat to explain observed global warming.
8. That Greenhouse-warming theory is physically impossible for many well-observed reasons.
9. That all observed global warming throughout Earth history can be explained much more directly and clearly by ozone depletion than by greenhouse-warming theory. In fact, greenhouse-warming theory cannot explain the very clearly observed rapid warming and slow cooling in highly erratic sequences that average, at many times in Earth history, just a few thousand years in duration.
10. That humans caused the warming from 1970 to 1998 by depleting the ozone layer by manufacturing CFCs.
11. That chlorine and bromine from large, hot, basaltic lava flows caused the much more rapid warming since 2014.
12. That greenhouse-warming theory cannot explain why temperatures were relatively constant from 1945 to 1970, rose significantly from 1970 to 1998, remained relatively constant from 1998 to 2013, and rose at a very high rate from 2014 to 2016. Meanwhile, concentrations of CO_2 rose steadily at ever increasing rates.
13. That ozone-depletion theory explains Artic amplification and why warming in the northern hemisphere was twice as great as in the southern hemisphere, while the greatest regional warming in 1100 years was along the Antarctic Peninsula.

All of these conclusions are based on direct and clear observations of Nature. There are few more original papers that this one. This paper bears no semblance to “popular science”, whatever that is. This paper shows that all “rigorous quantitative calculations or analysis of measurements” published in JGR Atmospheres and elsewhere are based on mistaken mathematics—on a fundamental misunderstanding about what heat is.

Rejection letter from Science

30-Apr-2018
Dear Dr. Ward,

Thank you for submitting your manuscript "Greenhouse gases cannot cause observed global warming—they absorb only spectral lines, not heat" to Science. Because your manuscript was not given a high priority rating during the initial screening process, we have decided not to proceed to in-depth review. The overall view is that the scope and focus of your paper make it more appropriate for a more specialized journal. We are therefore notifying you so that you can seek publication elsewhere.

We appreciate that you requested transfer to another Science family journal; however, based on our experience, this manuscript is unlikely to succeed at another of our journals. Therefore, we consider it would be in your best interest to submit elsewhere.

Sincerely,
H. Jesse Smith, Ph.D.
Senior Editor
Science

Rejection letter from Nature Communications

May 9, 2018
Dear Dr Ward,

Thank you for submitting your manuscript entitled "Greenhouse gases cannot physically cause observed global warming—they absorb only spectral lines, not the required heat". Regretfully, we cannot publish it in Nature Communications.

It is our policy to decline a substantial proportion of manuscripts without sending them to referees so that they may be sent elsewhere without further delay. Such decisions are made by the editorial staff when it appears that papers do not meet the criteria for publication in Nature Communications. These editorial judgments are based on such considerations as the degree of support for claims made and novelty of the claims in relation to the existing literature.

In this case, while we find your theory interesting, I am afraid many of your claims have already been published and broadcast in other forms of media, undermining their novelty. Furthermore, in order to refute such a longstanding and widely accepted concept, a sufficiently compelling alternative explanation is required, which we unfortunately find lacking in the current work.

I am sorry that we cannot be more positive on this occasion and thank you for the opportunity to consider your work. I wish you all the best in attaining publication elsewhere.

Best regards,
Dr Lewis Collins
Senior Editor
Nature Communications