Preliminary study on the essence of temperature, heat and energy

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[abstract]: through the analysis of the nature of temperature and heat, I found that temperature is not the sign of the average kinetic energy of molecular thermal motion, but related to the frequency corresponding to the peak intensity of thermal radiation, and the temperature is positively correlated with the main frequency of molecular thermal motion. Based on this, the physical phenomena such as constant temperature but absorbing or releasing a large amount of heat during the phase transition of most substances can be well explained. At the same time, the physical phenomena such as the inverse relationship between specific gravity and specific heat of most solid materials are predicted and explained. Heat is a measure of the degree of change of molecular kinetic energy in the process of molecular temperature convergence. On the basis of a new understanding of temperature and heat, this paper intends to reinterpret and understand entropy increase, heat death and the second law of thermodynamics.

Energy is the most common term in physics, but there are still many disputes and misunderstandings about the nature of energy. In this paper, the essence of energy is discussed in depth, and its physical significance is expounded on this basis. At the same time, by expounding the essential meaning of temperature and heat, it is applied to explain the abnormal correlation between temperature and heat during the phase change of water and the abnormal temperature distribution in various layers outside the sun.

On the basis of re-examining the differences between the two forms of Planck's blackbody radiation formula (frequency, wavelength and energy intensity respectively), the relationship between blackbody temperature and the frequency corresponding to the peak radiation intensity is re-deduced, and the temperature of the sun surface is calculated to be 9932.78℃ by using this relationship, instead of 5522.85℃ calculated by Wien's law. The reason of uneven surface temperature of artificial earth satellite is also discussed.

Chapter one

How to understand and interpret entropy increase and the second law of thermodynamics

First， Definition of temperature and heat

1. Definition of temperature

Temperature is a physical quantity indicating the degree of heat and cold of an object, and it is the intensity of thermal motion of an object molecule in a microscopic view. Temperature can only be measured indirectly through some characteristics of an object changing with temperature, and the scale used to measure the temperature value of an object is called a temperature scale.

From the point of view of molecular motion theory, temperature is a sign of the average kinetic energy of molecular motion of an object. Temperature is the collective expression of a large number of molecular thermal movements, which has statistical significance. For individual molecules, temperature is meaningless[Excerpted from Encyclopedia of Thickness].

2.Definition of heat

Heat means that when the change of system state comes from the destruction of thermal equilibrium conditions, that is, from the temperature difference between the system and the outside world, we say that there is thermal interaction between the system and the outside world. As a result, energy is transferred from a high-temperature object to a low-temperature object, and the energy transferred at this time is called heat[Excerpted from Encyclopedia of Thickness].

Second, the real meaning of the temperature and heat

1, The real meaning of the temperature

According to the Planck blackbody radiation formula：

$$E = \frac{8\pi h\nu^3}{C^3}\frac{1}{e^{\frac{h\nu}{kT}}-1}$$

（Formula 1-1）

It is known that the frequency v_m corresponding to the maximum radiation intensity E is closely related to the temperature T of the object. We can derive (formula 1-1) from v and make the derivative equal to 0. There are：

$$\frac{8\pi h}{C^3}\left(\frac{3v_m^2}{e^{\frac{hv_m}{kT}}-1}-\frac{hv_m^3 e^{\frac{hv_m}{kT}}}{kT(e^{\frac{hv_m}{kT}}-1)^2}\right)=0$$

（Formula 1-2）

Divide both sides of (formula 1-2) by constants and the same term, and simplify to get：

$$(3-\frac{hv_m}{kT})e^{\frac{hv_m}{kT}}-3=0$$

（Formula 1-3）

The relationship between the temperature of the object and the frequency corresponding to the peak value of radiation energy can be established by (Formula 1-3): T=f(v_m)：

$$T=\frac{hv_m}{2.821439372k}=0.354429023\frac{hv_m}{k}$$

（Formula 1-4）

As shown in Figure 1-1, Planck's blackbody radiation formula is basically applicable to the thermal radiation of general objects, including the solar radiation spectrum. Therefore, the law that the temperature of an object is related to the frequency corresponding to the peak of the thermal radiation spectrum of the object is universal and can be applied to general physics research. It can be seen that the temperature of an object is not determined by the average kinetic energy of its molecules, but by the frequency corresponding to the peak of thermal radiation. However, the peak frequency of blackbody radiation spectrum is only related to the dominant molecular thermal motion frequency (hereinafter referred to as "the main frequency of molecular thermal motion"), and has nothing to do with the molecular mass, the average velocity of thermal motion, momentum and kinetic energy (which is why Planck's blackbody radiation formula has nothing to do with the material type). Therefore, we have reason to understand that temperature is only related to the peak frequency of blackbody radiation spectrum, and the peak frequency is only related to the main frequency of molecular thermal motion. Therefore, there are: temperature is only related to the main frequency of molecular thermal motion. It can be seen that temperature is not directly proportional to the kinetic energy of molecules, that is, it is not a sign of the average kinetic energy of molecules, but a sign of the main frequency of molecular thermal motion.

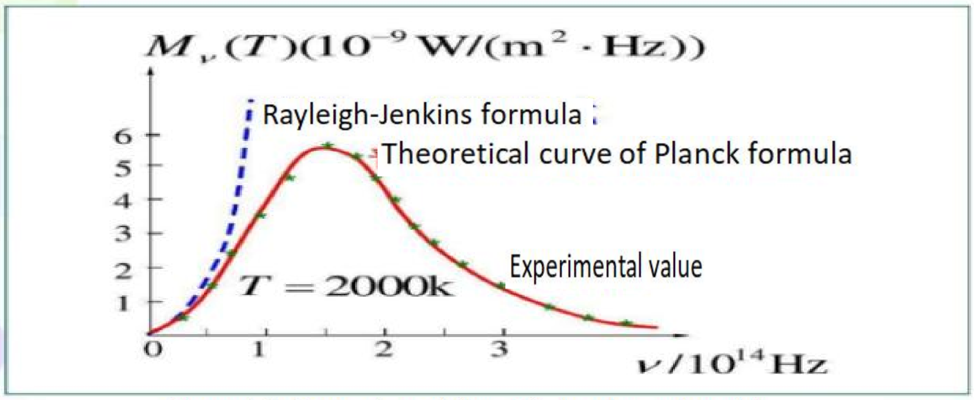

Figure 1-1: Comparison of theoretical and experimental data of the relationship between blackbody radiation intensity and frequency

2. The true meaning of heat

Heat refers to the amount of energy exchange generated in the process when materials with different temperatures contact or interact with each other through electromagnetic radiation, and the high-temperature objects will heat up the low-temperature objects and cool themselves. However, from the above re-understanding of the meaning of temperature, we will find that temperature is only related to the main frequency of thermal motion of molecules. Therefore, if a high-temperature object transfers heat to a low-temperature object, it should be the high-temperature object molecules that increase the thermal motion frequency of the low-temperature object molecules, and at the same time reduce their own frequency to achieve frequency synchronization and temperature equality. It can be seen that whether it is heat conduction or heat radiation, heat is transferred from high molecular thermal motion frequency to low, and reaches the same temperature after the frequencies are equal.

3. The relationship between temperature and heat

In order to explain the relationship between temperature and heat, we choose water as the research object for detailed analysis.

Brief table of specific heat change of water　　Table 1

Serial number	Name	Status	Unit	Heat quantity (J)
1	Every 1 ℃ increase of ice below 0 ℃	Solid state	Kg	2060
2	Change 0 ℃ ice into 0 ℃ water	Solid-liquid mixture	Kg	335000
3	0~100℃ water rises by 1℃	Liquid	Kg	4219
4	Water at 100 ℃ becomes steam at 100 ℃	Gaseous and liquid mixture	Kg	2258000
5	Every 1 ℃ increase of water vapor above 100 ℃	Gaseous state	Kg	>4221 and increases with the increase of temperature

Heat calculation table of water　　Table 2

Temperature (K)	Specific heat (KJ/Kg•K)	Heat (KJ/Kg)	Status	备注
0	2060	0	Ice	Ignore the influence Of specific heat With temperature When the state of matter is constant
273.15		562689		
	4219	897689	Water	
373.15		1319589		
	4221	3577589	Gaseous	
473.15		3999689		

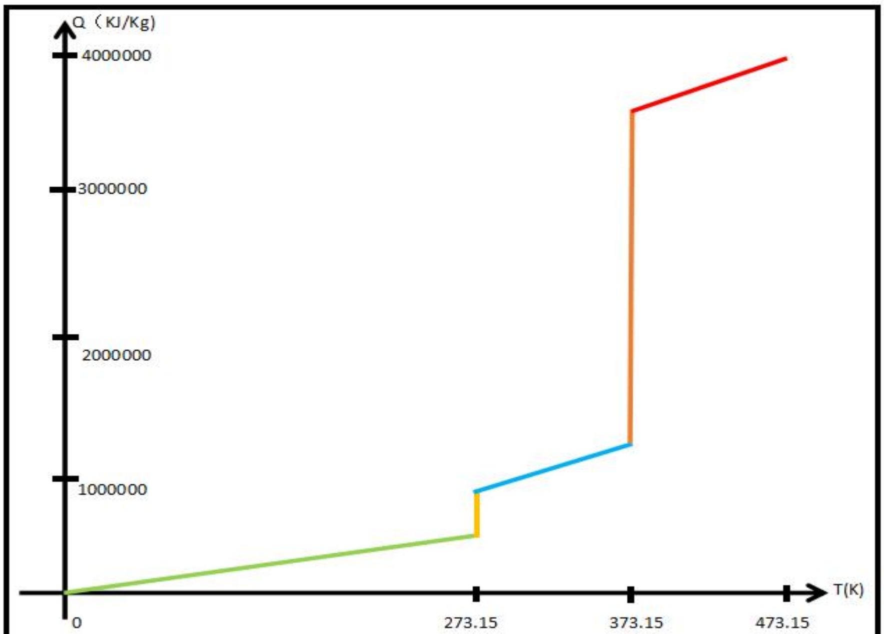

Figure 1-2:Diagram of the relationship between internal energy (heat capacity) and temperature of water

It can be seen from Table 1, Table 2 and Figure 1-2 that the temperature of water is not a simple linear relationship with the heat it carries. When water changes from solid to liquid or from liquid to gas, the relationship between heat and temperature is multivalued. Therefore, the temperature can not be directly used to express the heat level of the same substance! We must consider the state of matter, that is, the motion state of molecules or atoms and their relationships. Although the temperature of an object is positively related to the main frequency of its molecular thermal motion, it is also positively related to the average velocity, momentum and kinetic energy of molecular thermal motion, but it is not a single-valued function. The average velocity, momentum and kinetic energy of molecular thermal motion of water and ice or water and steam mixture at the same temperature can have many values.

Third, the fact that the supporting temperature is the main frequency mark of molecular thermal motion

1. The relationship between temperature and heat during phase transition

During the phase change of most substances, the temperature remains the same but will absorb or release a lot of heat. This is inconsistent with the sign that temperature is the kinetic energy of molecular thermal motion. For example, in the process of changing ice into water or water into steam, the temperature is 0℃ or 100℃, but it will absorb a lot of heat. The phenomenon that the increase of heat does not cause the temperature to rise shows that the temperature has a wireless or proportional relationship with the average kinetic energy of molecules, as shown in Tables 1 and 2 and Figure 1-2 above：

The above phenomena can be well explained by using temperature as a sign of the main frequency of molecular thermal motion: as a solid ice, its molecular spacing is small, its free motion is difficult and its thermal motion stroke is small; However, the distance between water molecules is large, the free movement is relatively easy, and the thermal movement stroke is large; The distance between water vapor molecules is larger, the free movement is easier and the thermal movement stroke is longer. Therefore, under the condition of constant thermal motion frequency, the kinetic energy of molecules of ice is the smallest, followed by water, and water vapor is the largest.

Therefore, when ice at 0℃ changes into water at 0℃, the kinetic energy of molecules increases greatly, so it is natural to absorb a lot of heat. It is the same for water at 100℃ to become steam at 100℃, and the heat absorbed is much greater than that from ice to water.

2. Relationship between specific gravity and specific heat of main metals

According to the positive correlation between temperature and the main frequency of molecular thermal motion, it can be inferred that the specific heat of a substance is inversely proportional to the specific gravity (the smaller the molecular spacing, the smaller the freedom and stroke of thermal motion, and the less heat is needed); It is proportional to the number of atoms per unit volume. It can be seen from Table 3 below that the product of specific gravity and specific heat is between 1.47 and 3.47 J/cm^3 *℃; Except for aluminum, the ratio of specific heat to atomic number per unit volume of other metals is between 1.325 and 3.264, which shows a certain regularity.

List of specific gravity, specific heat and relative atomic weight of main metals and their relationship — Table 3

Name	Silver	Aluminium	Iron/steel	Copper	Mercury	Lead	Zinc	Gold	Remarks
Specific gravity (g/cm^3)	10.49	2.7	7.87	8.89	13.6	11.34	7.14	19.32	
Specific heat (J/g*℃)	0.24	0.88	0.46	0.39	0.14	0.13	0.39	0.13	
Specific heat * specific gravity (J/cm3*℃)	2.52	2.38	3.62	3.47	1.90	1.47	2.78	2.51	
Relative atomic weight	107.87	26.98	55.845	63.546	200.59	207.2	65.39	196.97	
Number of atoms per unit volume (Specific gravity/relative atomic weight)	0.10	0.10	0.14	0.14	0.07	0.05	0.11	0.10	
Specific heat/number of atoms per unit volume	2.468	8.793	3.264	2.788	2.065	2.375	3.572	1.325	

3. The induction cooker and microwave oven have high thermal efficiency

Generally, the thermal efficiency of microwave oven and induction cooker is above 80%, the main reason is that the frequency of alternating electromagnetic field generated by microwave oven is just in the frequency band with large absorption coefficient of water molecules, and the frequency of water molecules is more likely to be increased to be close to the frequency of heated electromagnetic field. So that the alternating electromagnetic field generated by electric energy can give full play to the warming effect of water molecules in the heated object. At the same time, the energy wasted by mutual interference and mutual cancellation between different frequencies is reduced.

4. The crowd effect indicates that the frequency of molecular thermal motion can only be synchronized under thermal equilibrium

When huge crowds of people walk in a channel with limited width, synchronization with each other is the most efficient way to pass. Similarly, when in thermal equilibrium, the thermal motion frequencies of molecules in matter must be the same, so that the system will be stable and will not collide with each other to cause energy transfer and imbalance.

5. Principle of semiconductor refrigeration (heat)

When the cooler composed of two kinds of (N and P) semiconductors is energized and the electrons move from one end to the other, the temperature of the end is cooled because the vibration frequency of the supplementary electrons is lower than that of the original electrons, while the temperature of the end is increased when the electrons moving to the other end through the PN junction are accelerated by the electric field. This is the basic principle of semiconductor refrigeration (heat).

6.The principle of compression refrigeration (heat)

When gas is compressed, due to the decrease of molecular spacing, the frequency of thermal motion naturally rises and heats up. However, when the pressure is reduced, the molecular distance suddenly increases and the stroke increases, and the thermal motion frequency naturally decreases and the temperature drops. During this period, there was external heat exchange, but the reason for the drastic change of temperature was the change of molecular thermal motion stroke, which led to the change of thermal motion frequency and temperature.

Fourth， Analysis of the relationship between thermal radiation frequency, electromagnetic forced heating and molecular thermal motion frequency

1. The relationship between thermal radiation frequency and molecular thermal motion frequency

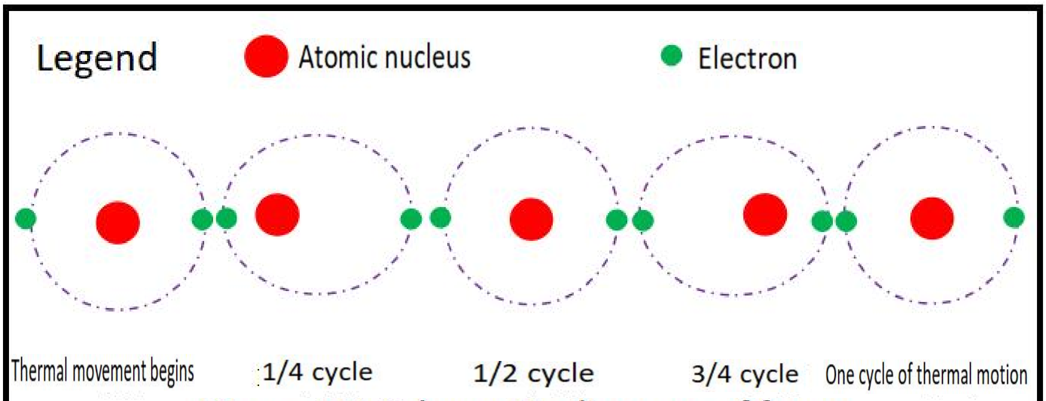

Figure 1-3:Schematic diagram of force analysis during atomic thermal motion

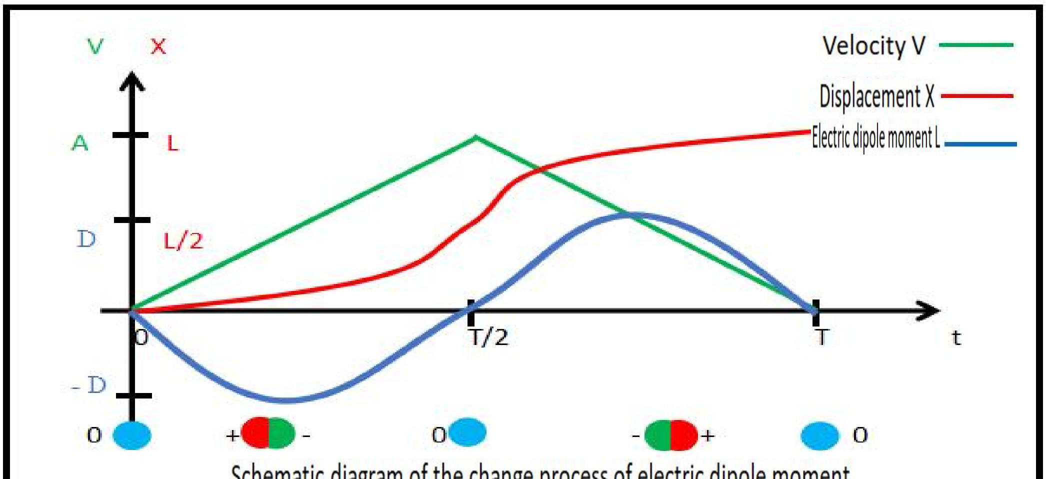

Figure 1-4:Schematic diagram of atomic velocity and displacement distance change in one cycle of thermal motion

In the process of molecular thermal motion, a specific molecule is impacted by neighboring molecules, which changes its state of motion and accelerates its linear motion until other molecules on the other side are hindered and decelerate its linear motion until it stops temporarily. This process is a cycle of molecular thermal motion. The stress of atoms in molecules during this period is shown in Figure 1-3 above: at the initial stage of collision, electrons are first stressed and change their motion state, and the change of electron motion state forces the nucleus to change its motion state. During this time, the atom will become an electric dipole. After moving for a certain distance, when the speed of the electron and the nucleus is synchronized, the atom returns to the electrically neutral state; After moving for a certain distance, it will be hindered by neighboring molecules on the other side and decelerate. If it is just the opposite at first, the electron first begins to decelerate and forces the nucleus to decelerate. In this process, the atom becomes an electric dipole again, but the polarity is just the opposite. Until the atom temporarily stopped moving, the atom returned to the neutral state. Therefore, one cycle of thermal motion of molecules makes the atoms in them become electric dipoles twice, which will radiate the electromagnetic field of electric dipoles twice, and also just complete one cycle of electromagnetic radiation, that is, the frequency of thermal motion is equal to the radiation frequency. See Figure 1-4 above for details.

2. The relationship between electromagnetic forced heating and molecular thermal motion frequency

When an externally changing electromagnetic field acts on a substance, the atoms in its molecules will be affected by the additional and changing electromagnetic field and change their motion mode and state. Because the charges carried by the nucleus and the electrons in the atom are different and the mass difference is huge, under the action of the same externally changing electromagnetic field, their motion states change in opposite directions, and the range of change is obvious: as shown in Figure 5 below, the first half of the externally changing electric field will make the electrons and the nucleus move away from each other to form an electric dipole; In the second half of the week, the atoms form electric dipoles with opposite polarities. Its change law is the same as that of molecular thermal motion. When atoms are forced by the external changing electric field, electrons and nuclei will eventually synchronize with the frequency of the external electromagnetic field, thus achieving the purpose of heating.

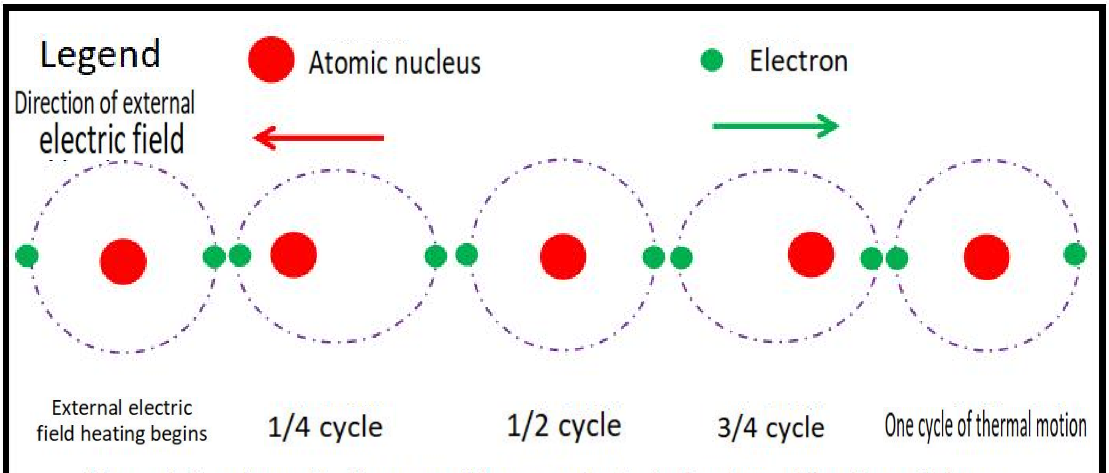

Figure 1-5: schematic diagram of force analysis during forced heating of atoms

Fifth, The real meaning of entropy increase and the second law of thermodynamics

1, The real meaning of the law of entropy increase

1.1. The law of entropy increase: the law of entropy increase means that the flow of heat from high temperature objects to low temperature objects is irreversible. It shows that the world will become more and more disorderly and chaotic.

1.2. Real meaning: According to the positive correlation between temperature and the main frequency of molecular thermal motion, the so-called heat flowing from high-temperature objects to low-temperature objects is only the change of molecular or atomic thermal motion frequency, which leads to the change of its kinetic energy. That is, the real scene of heat exchange between high-temperature objects and low-temperature objects is that part of kinetic energy of high-temperature object molecules is transferred to low-temperature object molecules, which makes the temperature of low-temperature objects rise and the temperature of high-temperature objects drop. When they reach the synchronization of molecular motion frequency, the kinetic energy will no longer be exchanged. For objects with the same composition and state of matter, after they reach temperature equilibrium, the thermal motion frequency of molecules is equal, and the momentum and kinetic energy are equal; However, for objects with different material compositions or states, after they reach temperature equilibrium, the thermal motion frequencies of molecules are equal, but the kinetic energy is not necessarily equal. For example, although the temperature of ice-water mixture is 0℃, the average travel, speed, momentum and kinetic energy of ice molecules are far less than those of water molecules.

Although the direction of heat transfer in the process of temperature convergence between objects is irreversible from high temperature to low temperature, it does not mean that the world will become more and more disorderly and chaotic. Because there are two ways in this process: first, when solid objects exchange heat only by surface contact heat conduction or non-contact thermal radiation between liquid and gas substances, because there is no mixing process of molecules or atoms between objects, it is only a process of convergence of molecular and atomic thermal motion frequencies, and the order is not chaotic, but becomes more orderly because of mutually synchronous molecular thermal motion; Second, when liquids and gases are mixed with each other, although the process of mixing occurs due to the thermal movement of molecules, when the temperature equilibrium state is reached, the thermal movement frequencies of molecules also converge, and the overall order is better than before mixing. As for the confusion caused by the mixing process of liquid and gas, it is not caused by the change of temperature or the transfer of heat, but the necessity of molecular thermal movement. Even if two liquids and gases with the same temperature are mixed, the phenomenon of confusion will also occur, but there is no heat transfer in this process.

2. The possibility of heat death

2.1. The meaning of heat death: heat death is a hypothesis to guess the ultimate fate of the universe. According to the second law of thermodynamics, as an "isolated" system, the entropy of the universe increases with the flow of time, from order to disorder. when the entropy of the universe reaches the maximum, all other effective energy in the universe has been converted into thermal energy. the temperature of all matter reaches thermal equilibrium. This state is called heat death.

2.2, Possibility analysis: from the above analysis, we can see that the heat exchange process between objects is only the exchange process of molecular thermal kinetic energy. There are many factors that affect the kinetic energy of molecular thermal motion. Such as: the role of gravitation and electromagnetic force. At the same time, the macroscopic motion of matter and the non-thermal kinetic energy of the atoms, electrons and nuclei that make up the molecules are not taken into account in the thermal energy. Even if the object is at absolute zero degree, its macroscopic motion still exists, the electrons and nuclei in the atom are also moving, and there is still a huge kinetic energy of non-thermal motion. In particular, the energy of particles with mass is proportional to the product of mass and the square of the speed of light. This part of the energy is not taken into account. The most important thing is that there is a temperature gradient in objects, especially solids, that is, the temperature of the surface and interior of the same object is not exactly the same, and the performance of non-metallic materials is more significant than that of metal materials. This is why there is such a big temperature difference between the surface illuminated by the sun and the other side of the aircraft in space. That's why Parker's solar probe is so close to the sun and withstands the heat of more than a thousand degrees near the sun. Due to the existence of temperature gradient, when the external electromagnetic radiation on different surfaces is different, the thermal motion frequency of the surface molecules will converge with the peak frequency of the external radiation spectrum. When the aircraft in space faces the sun, the thermal motion frequency of the molecules on the surface of the aircraft will converge with the peak frequency of the solar spectrum, while on the other side, because the electromagnetic radiation is very weak, it is mainly cosmic background radiation and aircraft scattering and conduction. when the transfer efficiency of aircraft materials is not high, the temperature will be much lower than the sun-facing side.

From the above analysis, we can see that the conditions for a system or even the whole universe to achieve thermal silence are quite stringent, unless all matter in the universe is liquid and gas and gathers together. Otherwise, the state of motion will always change under the action of gravitation and electromagnetic force. The change of the motion state will change the thermal motion state of the molecules in the matter, resulting in a temperature difference. It will never be possible to equalize the temperature of all matter in the universe and produce a state of thermal silence.

3. Interpretation of the second law of thermodynamics

3.1. The second law of thermodynamics: heat can only be transferred from a high-temperature object to a low-temperature object spontaneously. The direction of heat transfer is opposite to that of temperature gradient.

3.2. Real meaning: Through the above analysis of temperature and heat, we can know that the so-called heat will be spontaneously transferred from a high-temperature object to a low-temperature object, which is essentially that when molecules with high thermal motion frequency meet or have electromagnetic interaction with molecules with low thermal motion frequency, their thermal motion frequencies will converge (only in this way can their motions be synchronized without or without interference with each other). That is to say, the movement frequency is high, and the movement frequency is low, until the two frequencies are the same.

To sum up, temperature is only positively related to the main frequency of molecular thermal motion of an object, but has nothing to do with the average stroke, speed, momentum and kinetic energy of molecular thermal motion! The process of heat transfer is essentially the process of convergence of molecular thermal motion frequencies. At the same temperature, the average velocity, momentum and kinetic energy of molecular thermal motion are positively related to the stroke of molecular thermal motion and the mass of molecules. These are the essential factors and characteristics of temperature, heat and their heat exchange.

chapter two

On the Essence and Significance of Energy

First, The definition of energy

Energy is a measure of the possible change of the temporal and spatial distribution of matter, which is used to characterize the ability of physical systems to do work. Energy exists in many different forms; according to the different forms of motion of matter, energy can be divided into mechanical energy, chemical energy, thermal energy, electric energy, radiation energy, nuclear energy, light energy, tidal energy and so on. These different forms of energy can be transformed into each other through physical effects or chemical reactions. The field also has energy. The essence of energy is a physical quantity measured in four-dimensional space in the physical sense, similarly, momentum, which is measured in three-dimensional space, and mass, which is measured in two-dimensional space, and so on. They are all material properties of matter in different dimensions.。

Energy is a measure of material motion transformation, referred to as "energy". Everything in the world is in constant motion. Among all the attributes of matter, motion is the most basic attribute, and other attributes are the concrete manifestations of motion. Energy is a measure of the ability of a physical system to do work. Energy is a unified measure to measure the movement scale of all substances [from Baidu Encyclopedia].

Second, The form of energy

Energy can be divided into mechanical energy (kinetic energy and potential energy), chemical energy, thermal energy, electric energy, radiant energy, nuclear energy and light energy.

1、Kinetic energy

Kinetic energy is the energy possessed by an object due to its mechanical motion.

$E_k = 0.5mv^2$ Among them: E_k for kinetic energy, m for quality, v for speed

2、Potential energy

Typical potential energy includes gravitational potential energy, gravitational potential energy and elastic force potential energy.

3、Chemical energy

Energy released or absorbed when a substance undergoes a chemical change (chemical reaction).

4、Electric energy

The potential energy between positive and negative charges due to the action of electricity.

5、Radiant energy

Refers to the energy of light and electromagnetic fields。

6、Nuclear energy

The binding energy of nucleons in the nucleus, which will be released into kinetic energy of reaction products in the nuclear fission or fusion reaction of atoms.

Third, the characteristics of energy

1. The function of quality

Mechanical energy (kinetic energy and potential energy) and nuclear energy are all related to the quality of matter.

Mechanical energy including kinetic energy and potential energy is related to the mass of matter, that is to say, only matter with mass can have kinetic energy and potential energy.

Nuclear energy is the fission or fusion reaction of the nucleus in matter, which causes the reaction products to gain great motion speed and move outside the nucleus to produce powerful kinetic energy. Therefore, it is also related to the quality of matter.

To sum up, the substance with mass is the carrier of energy and the medium of energy conversion and transmission.

2. The function of electric charge

Chemical energy, electric energy, radiant energy and nuclear energy are all related to the charge of matter.

Chemical energy is a new substance formed by two substances after chemical reaction. In this process, the outer electrons of two or more elements change in their motion modes and motion regions, which leads to changes in the motion states of themselves and other substances around them.

Electric energy is the directional movement of electrons in a substance, which leads to the change of the magnetic field and electric field in the surrounding space, thus leading to the change of the motion state of itself and other surrounding substances.

Radiant energy is the process in which the motion states of electrons and nuclei in a substance change regularly, so that the electric field and magnetic field in the surrounding space change with time, which leads to the change of the motion states of itself and other surrounding substances.

In the process of nuclear fission or fusion reaction, it is generally accompanied by the generation and extinction of charged particles and great changes in the state of motion, which leads to great changes in the electromagnetic field in the space around the nucleus. This leads to a change in the state of motion of itself and other matter around it.

To sum up, the function of charge is that the charged substance changes the electromagnetic field near its position, which in turn leads to the change of the motion state of itself and the surrounding charged body. From a macro point of view, this effect is like transferring the kinetic energy of charged matter to other nearby substances and causing energy exchange. But in essence, it is still the change of the motion state of matter with mass that leads to the occurrence of energy transfer. Charge itself does not have the basic properties and characteristics of energy, nor is it the carrier of energy.

3, The action of movement

Kinetic energy, potential energy, chemical energy, electric energy, radiant energy and nuclear energy are all related to the motion of charged substances or/and charged substances.

Kinetic energy is undoubtedly the energy directly related to the macroscopic motion of matter with mass.

Potential energy is also the energy related to the change of the spatial position of the matter with mass, which leads to the change of its own motion trend and ability.

Chemical energy is the energy directly related to the change of the movement mode of atoms and molecules in the micro-world of matter with mass.

Both electric energy and radiant energy are energy that the movement of charged particles with mass leads to the change of electromagnetic field at the position of the surrounding charged body, which leads to the change of its motion state.;

Nuclear energy refers to the change of the motion state of basic particles such as protons and neutrons, which constitute the nucleus, during the fission or fusion of the nucleus with mass, thus leading to the change of energy.

To sum up, when the material with mass moves macroscopically or microscopically, it will lead to the change, transformation and transmission of energy.

4. the function of the frame of reference

All the energies related to velocity and spatial position, such as kinetic energy, potential energy, chemical energy, electric energy, radiant energy and nuclear energy, are related to the frame of reference. The same substance has different values of energy at the same time in different frames of reference. For example, the kinetic energy of a relatively stationary object in a frame of reference is 0, while in another frame of reference that moves in a straight line with respect to this frame of reference, the kinetic energy of the object is not zero.

Fourth, The nature of the energy

From the above analysis, we can see that no matter what kind of energy it is, it is closely related to the matter with mass and charge. On further examination, we will find that the role of electric charge in energy is very limited, although in the micro world, the role of electric charge is much greater than that of gravity. Whether the gravitation causes the change of the motion state of the matter with mass to obtain the change of kinetic energy or potential energy, or the electric field changes the motion state of the matter with mass to obtain the change of kinetic energy or potential energy, or the magnetic field changes the motion state of the magnetic and mass matter and obtains the change of kinetic energy or potential energy. Or the chemical reaction causes the change of the binding state of the atom or molecule with mass, which leads to the change of the kinetic energy or potential energy of the matter, or the fission / fusion reaction changes the structure of the nucleus with mass, which leads to the change of the kinetic energy or potential energy of the matter, and so on. The most crucial element is that matter must have mass in order to have the change of kinetic energy and potential energy. Therefore, the essence of energy is a measure of the ability of mass matter to maintain and change the state of motion and spatial position. That is to say: no mass, no energy. Only the matter with mass is the carrier of energy, and it can also become the carrier of energy transfer and transformation.

Fifth, the re-understanding of energy

From the above discussion, we can see that energy must be carried by objective entities with mass and transmitted among substances with mass. At the same time, the transfer of energy is often a process in which a substance with a high moving speed transfers kinetic energy to a substance with a low moving speed and makes the two energies converge. For example, the process in which a high-temperature substance raises the temperature of a low-temperature substance while lowering its own temperature means that the moving speed of the atoms or molecules of a high-temperature substance is higher than that of a low-temperature substance. When the molecules or atoms of a high-temperature substance come into direct contact with the atoms or molecules of a low-temperature substance, an elastic collision class will be formed, which will increase the speed of a low-speed molecule or atom and decrease the speed of a high-speed atom or molecule. If the two substances are not in direct contact and there is no intermediate (vacuum) between them, the electromagnetic wave frequency emitted by the high-temperature substance is higher than that of the low-temperature substance, and the high-frequency electromagnetic wave will increase the vibration frequency of the atoms or molecules of the low-temperature substance, while the low-frequency electromagnetic wave emitted by the low-temperature substance will decrease the vibration frequency of the atoms or molecules of the high-temperature substance. The result of the interaction between the two sides will reach an equilibrium state-the temperature tends to be equal, that is, the frequencies of electromagnetic waves of the two sides tend to be the same. This is the process that the high-temperature substance transfers heat to the low-temperature substance and makes the temperature converge, but the heat in it is not a particle. The heat is only a measure of the thermal motion of atoms or molecules in the substance, and it is also a form of expression of the momentum of the substance. Another example is the collision between macroscopic objects, the collision between a fast-moving object and a slow-moving or stationary object, and the collision between two objects moving in opposite directions. Whether it is a complete elastic collision or an incomplete elastic collision, the object with a high moving speed always increases the moving speed of the object with a low moving speed, while its own speed decreases or stops moving or moves in the opposite direction.

From the above analysis, we can sum up the following key points of energy：

1. The carrier of all energy must be matter with mass, and matter without mass cannot be the carrier of energy.

2. The energy transfer is from the energy carrier with high moving speed to the energy carrier with low moving speed.

3. Energy conversion is essentially a process of reorganization of the internal structure and motion mode of matter.

Sixth, several common mistakes in the understanding of energy

1. The mistake of pure energy theory

1.1. Dark energy theory: There is a view that the total mass of the universe is (100%)≌ (baryon+lepton) (4.4%)+ hot dark matter (≤2%)+ cold dark matter (≈20%)+ dark energy (≈74%). Among them, dark matter is a substance that can not interact with electromagnetic field but can interact with gravity; Dark energy is a substance that can neither interact with electromagnetic field nor with gravity, but it also has mass. We know that there are two basic characteristics of a substance with mass: one is the ability of inertia, that is, the ability to keep its own motion state unchanged when there is no external force or the sum of external forces is zero; Second, it has the ability of gravitation. But dark energy does not produce universal gravitation, but produces universal repulsion, which makes the universe expand rather than contract. At present, the result that the celestial redshift obtained by astronomical observation is proportional to the distance from the earth is wrongly interpreted as the basis for the expansion or accelerated expansion of the universe: the celestial redshift obtained by astronomical observation is not the only proof that the speed of celestial bodies leaving the earth is proportional to the distance from the earth (see http://blog.163.com/pxt1961@126/blog/static/ for details). 2984317920182911363640 My blog post "A Preliminary Approach to Revealing the True Image of the Red Shift of Celestial Bodies Outside the River —— Application of Multi-factor Analysis in the Red Shift of Celestial Spectra").

1.2. Field energy theory： There is a view that gravitational field, gravitational field and electromagnetic field are all energy fields and have energy density. That is to say, there is gravitational energy or gravitational energy or electromagnetic energy at any point in the surrounding space of a mass or charged object. There is an obvious mistake in this view: because gravity and electromagnetic force are remote forces, a point mass or charge can produce gravity or electromagnetic force at any space position in the whole universe. Can we say that the energy of a point mass or charge is distributed in the whole universe? Gravitation and electromagnetic force are both forces that can be superimposed by vectors. When the gravitational force or electromagnetic force of two or more point masses or charges at the same time and the same spatial position cancel each other out, can we say that gravitational energy and electromagnetic energy can cancel each other out and disappear?

2. The authenticity of the law of conservation of energy

The law of conservation of energy, the first law of thermodynamics, means that the total energy in a closed (isolated) system remains constant. Generally speaking, the total energy is no longer the sum of kinetic energy and potential energy, but the total amount of static energy (inherent energy), kinetic energy and potential energy. It can be expressed as: the change of the total energy of a system can only be equal to the amount of energy coming in or out of the system. The total energy is the sum of the mechanical energy, thermal energy and any form of internal energy except thermal energy of the system. If a system is in an isolated environment, it is impossible to have energy or mass coming in or out of the system. For this case, the law of conservation of energy is expressed as: "the total energy of the isolated system remains unchanged." Energy is neither generated nor disappeared out of thin air, it is only transformed from one form to another, or transferred from one object to another, while the total amount of energy remains the same [from Baidu Encyclopedia].

So, is the law of conservation of energy really true? Let's first discuss the kinetic energy of a single object.

According to the definition of kinetic energy, the kinetic energy of an object is equal to half the product of the square of mass and velocity. Then, for an atom, such as a hydrogen atom, its kinetic energy should be equal to half of the square product of the total mass of electrons and nuclei and their moving speed. But the problem is that there are many, even countless, velocities of electrons and nuclei (relative to different reference frames)：

2.1, kinetic energy varies with different research areas

Without considering the gravitational field and electromagnetic field of the atom's space position, there are: atomic speed (the moving speed of the atom composed of electrons and nuclei in different reference frames as a whole), electronic speed (the moving speed of electrons around the nucleus), nuclear speed (the moving speed of the nucleus around the center of mass of the atom), proton and neutron speed (the moving speed of neutrons and protons in the nucleus), The movement speed of quarks in protons and neutrons (nuclear fission releases α and β rays and the movement speed is amazing, indicating that before fission, its movement speed is not zero, and it should be not lower than the exit speed after fission (fission is a process of slowing it down rather than accelerating it)).

If we consider the gravitational field and electromagnetic field of the atom's space position (especially the changing electromagnetic field and the constant movement of other atoms around the atom lead to the change of the gravitational field and electromagnetic field of the atom's space position with time), there are: the overall speed, electron speed, nucleus speed, proton and neutron speed in the nucleus, quark speed of protons and neutrons that change with time under the action of changing gravitational force and electromagnetic force, etc. Usually, the overall motion of atoms or molecules is manifested by thermal motion-a seemingly chaotic motion. The higher the temperature of an object, the more intense the thermal motion.

Since an object composed of atoms or molecules has many kinds of velocities, does its kinetic energy also have many values? This should be self-evident. At the same time, the velocity of the same object in different reference frames is also different, and its kinetic energy is of course different.

2.2. Non-scalar nature of momentum and kinetic energy

Because kinetic energy is directly related to the speed of motion, but the speed of motion is vector rather than scalar. Therefore, kinetic energy is naturally non-scalar. For example, when two objects with the same mass (M) but the same velocity (V) but opposite directions collide completely, there are：

Assume that the velocities after collision are v_1 and v_2

Conservation of momentum： $mv-mv=mv_1+mv_2$ （Formula 2-1）

Energy conservation： $0.5mv^2+0.5mv^2=0.5mv_1^2+0.5mv_2^2$ （Formula 2-2）

According to (formula 2-1)： $mv_1+mv_2=0$； $v_1+v_2=0$； $v_2=-v_1$ （Formula 2-3）

According to (formula 2-2)： $2v^2=v_1^2+v_2^2$； （Formula 2-4）

Replace (formula 2-3) into (formula 2-4)： $v^2=v_1^2$ So there is：

$v_2 = -v_1 = v$ （Formula 2-5）

According to (Formula 2-5), momentum and kinetic energy are conserved before and after the complete elastic collision. That is, the total momentum and total energy before and after the collision are respectively：0 and mv^2。

Let's change a frame of reference to analyze the above case: in a frame of reference that is stationary relative to one of the objects, the moving speed of the object is 0 and the moving speed of the other object is 2v (without considering the so-called relativistic effect), then the above (Formula 2-1) ~ (Formula 2-5) should be modified as follows：

Conservation of momentum：$2mv=mv_1+mv_2$ （Formula 2-1′）

Energy conservation：$2mv^2=0.5mv_1^2+0.5mv_2^2$ （Formula 2-2′）

According to（Formula 2-1′）：$v_1+v_2=2v$； $v_2=2v-v_1$ （Formula 2-3′）

According to（Formula 2-2′）：$2v^2=0.5v_1^2+0.5v_2^2$； （Formula 2-4′）

Replace（Formula 2-3′） into（Formula 2-4′）：$v_1(v_1-2v)=0$； So there is：

$v_1=0$、$v_2=2v$ or $v_2=0$、$v_1=2v$ （Formula 2-5′）

From (Formula 2-5'), it can be known that momentum and kinetic energy are conserved before and after a completely elastic collision. That is, the total momentum and total energy before and after the collision are respectively：2mv and $2mv^2$

In the constant velocity reference system of two objects moving in opposite directions, the sum of momentum is 0 and the sum of kinetic energy is mv^2； ; However, in a frame of reference that is stationary relative to one of the substances, the total momentum is 2mv and the total kinetic energy is $2mv^2$. That is, the total momentum changes from 0 to 2mv, and the total energy changes from mv^2 to $2mv^2$.

Thus it can be seen that the energy and momentum of the same system are not fixed, but related to the frame of reference.

For another example, an object with a mass of m moves in a circle at a speed of v_1 while moving in a straight line at a speed of v_2, as shown in Figure 2-1 below. When it is in the four positions of A, B, C and D in the figure, its momentum and kinetic energy should be respectively：

When in position A： $P=m(v_2-v_1)$ $E_k=0.5m(v_2-v_1)^2$;

When in position B： $P=m(v_2^2+v_1^2)^{1/2}$ $E_k=0.5m(v_2^2+v_1^2)$;

When in position C： $P=m(v_2+v_1)$ $E_k=0.5m(v_2+v_1)^2$;

When in position D： $P=m(v_2^2+v_1^2)^{1/2}$ $E_k=0.5m(v_2^2+v_1^2)$;

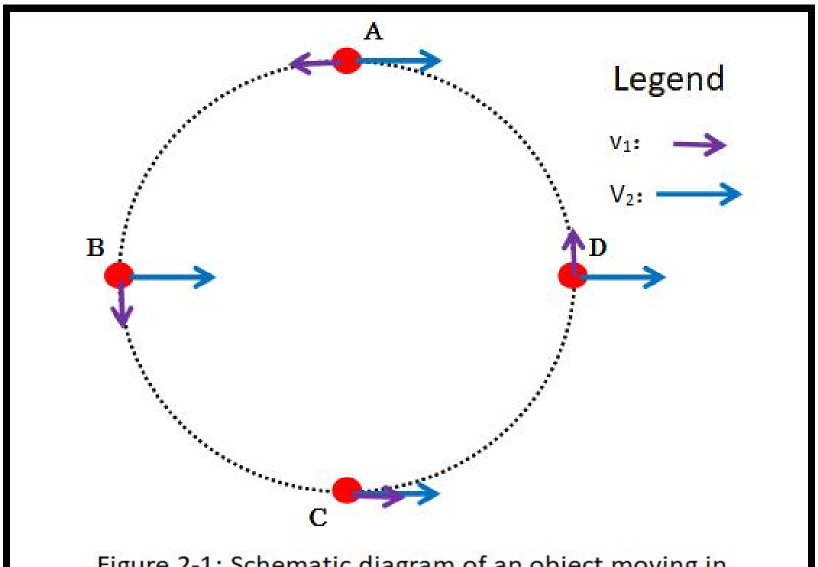

Figure 2-1: Schematic diagram of an object moving in a circle while moving in a straight line at a uniform speed

From the above analysis, we can see that although an object moving in a straight line at a uniform speed while making a circular motion is only constrained by a centripetal force that does not do work, its energy still varies with the position of time or space. That is, we cannot directly add the momentum of the circumferential motion of an object to the kinetic energy of the linear motion, but to calculate the kinetic energy after the velocity synthesis.

2.3, kinetic energy under the condition of synthetic speed

The magnitude and direction of the velocity of any particular object is directly related to the frame of reference in which the observer or observation device is located. Therefore, the kinetic energy which is directly related to the velocity of the object is also directly related to the frame of reference. That is to say, the kinetic energy of any particular object is not the property of the object itself, but related to the relative motion between the observation device and the object.

For example, when a passenger on a moving plane or train is at rest, the kinetic energy is 0. But relative to the ground, its kinetic energy is not zero, but related to the square of the speed of the plane or train and the weight of the passengers. If the weight of the passenger is m, the speed of the plane or train relative to the ground is v, and the speed of the passenger on the plane or train is u, then on the plane or train, the momentum of the passenger is: $0.5mu^2$. But relative to the ground, its momentum is：$0.5m(v+u)^2$.

Since the speed of the observation device relative to the object can be any value (regardless of whether it can be greater than the speed of light C for the time being), it can be concluded that the speed of a specific object is the speed of the observation device, and there can be any number of observation devices and their speeds relative to the object, so the kinetic energy of the object measured by each observation device is different, and there are also any number of kinetic energy values.

2.4. Directionality of momentum

Although the direction of motion can not be taken into account when calculating the momentum of an object, the momentum of an object is directional and its direction is the same as that of motion. Therefore, in the moment when two billiards collide, if the centroid of the hit ball is not in the direction of the motion line of the center of mass of the sports ball, the hit ball and the hit ball will move in different directions respectively. As shown in figure 2-2 below：

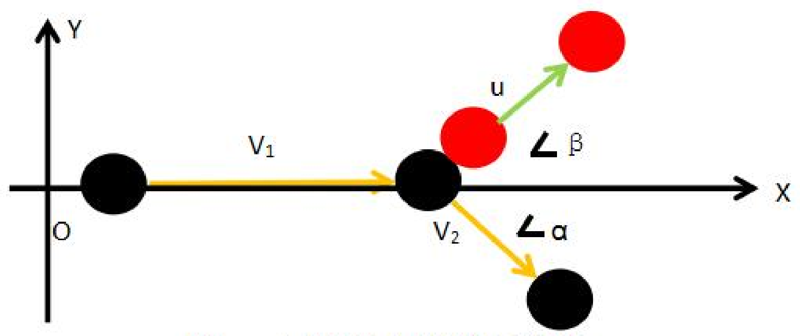

Figure 2-2: Schematic diagram of non-head-on collision of two balls

Assume that the mass of the moving ball and the hit ball are both m, and the velocity of the moving ball before collision is V_1; The velocity of the moving ball after collision is v_2, the velocity of the struck ball is u, the change angle of the moving direction of the moving ball is α, and the included angle between the moving direction of the struck ball and the moving direction of the moving ball before collision is β. Then there is：

A, when the momentum is a vector

Conservation of momentum:

horizontal direction: $mv_1=mv_2\cos\alpha+mu\cos\beta$ $v_1=v_2\cos\alpha+u\cos\beta$ (Formula 2-6)

Vertical direction: $0=mv_2\sin\alpha-mu\sin\beta$ $0=v_2\sin\alpha-u\sin\beta$ (Formula 2-7)

Kinetic energy conservation: $0.5mv_1^2=0.5mv_2^2+0.5mu^2$ $v_1^2=v_2^2+u^2$ (Formula 2-8)

It can be known from (Formula 2-7) that $v2=u\sin\beta/\sin\alpha$ can be substituted into (Formula 2-6):

$u=v_1\sin\alpha/(\sin\beta\cos\alpha+\sin\alpha\cos\beta)$ $v_2=v_1\sin\beta/(\sin\beta\cos\alpha+\sin\alpha\cos\beta)$

Substituting U and v_2 into (Formula 2-8) can be: $tg\,\alpha=ctg\,\beta$, and then we can get: $\alpha+\beta=90^0$

When $\alpha=45^0$, there are: $\beta=45^0$ $u=v_2=v_1/2^{1/2}$

Therefore, the total momentum after the collision is: $P=2mv_1/2^{1/2}\approx1.414mv_1$ and greater than that before the collision. In other words: to ensure the conservation of energy, we can't guarantee the conservation of total momentum! Only when the momentum is regarded as a vector and the vectors are superimposed and decomposed can the momentum conservation in different directions before and after the collision be guaranteed.

B, when the momentum is scalar

Conservation of momentum: $mv_1=mv_2+mu$ $v_1=v_2+u$ (Formula 2-6/)

Kinetic energy conservation: $0.5mv_1^2=0.5mv_2^2+0.5mu^2$ $v_1^2=v_2^2+u^2$ (Formula 2-8/)

It can be obtained by (Formula 2-6/): $u=v_1-v_2$, and it can be obtained by substituting (Formula 2-8/):

$V_2=0$ or $V_2=V_1$ Then there is: $u=V_1$ or $u=0$

Therefore, when momentum is regarded as a scalar rather than a vector, the conservation of momentum and kinetic energy can be established at the same time, only when two objects collide head-on, the moving ball becomes a static ball and the static ball becomes a moving ball. Just like when two balls collide in billiards, there are countless kinds of motion states of the two balls after the collision. In order to maintain the conservation of momentum and kinetic energy, momentum cannot be scalar, but must be vector.

When the momentum is regarded as a vector, the total momentum before and after the collision is not equal when the collision is not completely elastic. Generally, the total momentum after the collision will be greater than that before the collision.

To sum up, the law of conservation of energy must and only can be established in a specific frame of reference and closed system and in a specific research object and category.

2. The true meaning of heat and temperature

2.1. Temperature: a physical quantity that indicates the degree of cold and hot of an object. Microscopically, it is the violent degree of the thermal motion of an object's molecules. From the point of view of molecular motion theory, temperature is the symbol of the average kinetic energy of molecular motion of an object. Temperature is the collective expression of a large number of molecular thermal movements, which is of statistical significance. For individual molecules, temperature is meaningless. [from Baidu Encyclopedia].

2.2. Heat: It means that when the change of system state comes from the destruction of thermal equilibrium conditions, that is, when there is a temperature difference between the system and the outside world, we say that there is thermal interaction between the system and the outside world. As a result, energy is transferred from a high-temperature object to a low-temperature object, and the energy transferred at this time is called heat. Heat and work are two different forms of energy transfer that accompany the change of system state, and they are measures of different forms of energy transfer. They are all related to the intermediate process of state change, so they are not functions of system state.[from Baidu Encyclopedia].

2.3. The relationship between temperature and heat

2.3.1. The relationship between temperature and heat absorption (release) of water in

different states.

Relationship table of heat required for water temperature change

Serial number	Project name	Material state	Unit	Heat (J)
1	Under 0 ℃ ice every 1 ℃	Solid body	Kg	2060
2	0 ℃ ice into 0 ℃ water	Solid-liquid mixture	Kg	3350
3	0~100℃ water rises by 1℃	Liquid body	Kg	4200
4	Water at 100 ℃ becomes steam at 100 ℃	Gas-liquid mixture	Kg	2258000
5	Above 100 ℃ water vapour rise up every 1 ℃	Gas body	Kg	4200

As can be seen from the above table, there is no linear (i.e. non-single-valued function) relationship between temperature and heat absorbed or released by an object, mainly because the process of absorbing or releasing a certain amount of heat will not lead to temperature change during the state change of the object, when water changes from solid to liquid or from liquid to solid, and when water changes from liquid to gas or from gas to liquid.

2.3.2. Solar wind and object temperature in space near the sun

We know that the temperature of the photosphere on the surface of the sun is about 6000°C, while the temperature of the corona can reach 1-2 million C.. However, the temperature of objects at different distances from the sun is generally different. For example, the temperature of the satellite in outer space near the earth is above 200℃ on one side irradiated by sunlight, while the temperature on the other side is above MINUS 200℃. According to Parker's solar detector project team, when it is located at 6 million kilometers on the surface of the sun, the surface temperature of the detector in the solar illumination part is about 1400℃.

Why can't the temperature of objects (satellites and detectors) in the solar wind of tens or even millions of degrees for a long time always be the same as the temperature of the solar wind and reach thermal balance?

2.3.3. The true meaning of temperature

A, Only tangible material entities can have temperature, and there is no temperature for the subsidiary characteristics such as electromagnetism, gravitation and vacuum.

B. Temperature is the expression of the average level of thermal motion of a certain number of material entities, and the temperature of a single elementary particle or atom or molecule is meaningless.

C, The relationship between material radiation and temperature

According to the correlation between the peak radiation of the object and the temperature, the relationship between the temperature and the peak frequency of radiation can be obtained by deriving Planck blackbody radiation formula：

$$E = \frac{8\pi h v^3}{C^3(e^{\frac{hv}{kT}} - 1)} \quad \text{(Formula 2-9)}$$

Where E is radiation intensity; h is Planck constant; T is blackbody temperature; v is radiation frequency; C is the speed of light in vacuum; k is Boltzmann constant.

That is, take the derivative of (Equation 2-9) and make it equal to 0, then there is:

$$\frac{dE}{dv}\bigg|v_{\max} = \frac{24\pi h v_{\max}^2}{C^3(e^{\frac{hv_{\max}}{kT}} - 1)} - \frac{8\pi h v_{\max}^3}{C^3(e^{\frac{hv_{\max}}{kT}} - 1)^2} * \frac{h}{kT} * e^{\frac{hv_{\max}}{kT}} = 0 \quad \text{(Formula 2-10)}$$

Finishing (Formula 2-10) can be obtained:

$$3e^{\frac{h\nu_{max}}{kT}} - \frac{h\nu_{max}}{kT} * e^{\frac{h\nu_{max}}{kT}} - 3 = 0 \qquad \text{(Formula 2-11)}$$

To: $x = \frac{h\nu_{max}}{kT}$ Then (formula 2-11) can be simplified as:

$$(3 - x)\ e^{x} - 3 = 0 \qquad \text{(Formula 2-12)}$$

To get the numerical solution of type, we make: $f(x) = (3 - x)\ e^{x} - 3$ And numerical calculation, as shown in the table below:

It can be seen from the following table that at least two x values (a value between x = 0 and x = 2.82143927212x = 2.82143937213) can make (formula 2-12) valid, so there are:

$$\frac{h\nu_{max}}{kT} = 0 \qquad \text{(Formula 2-13)}$$

$$\frac{h\nu_{max}}{kT} \approx 2.82143937 \sim 2.82143938 \qquad \text{(Formula 2-14)}$$

$f(x)=(3-x)e^{x}-3$ Numerical calculation table

x	f(x)	x	f(x)	备注
−1000	−3.00000	−700	−3.00000	
−500	−3.00000	−300	−3.00000	
−100	−3.00000	−50	−3.00000	
−10	−2.99941	−7	−2.99088	
−5	−2.94610	−4	−2.87179	
−3	−2.70128	−2	−2.32332	
−1	−1.52848	−1	−0.87714	
0	0.00000	1	1.12180	
1	2.43656	2	4.38906	
2.82	0.01983	2.83	−0.11927	
2.821	0.00606	2.8215	−0.00084	
2.82143	0.00013	2.8214	−0.00001	
2.82143937	0.00000003	2.82143938	−0.00000011	
2.82143937212	0.00000000003	2.82143937213	−0.00000000011	
3	−3.00000	4	−57.59815	
5	−299.82632	7	−4389.53263	
10	−1.54E+05	50	−2.44E+23	
100	−2.61E+45	300	−5.77E+132	
500	−6.98E+219	700	−7.07E+306	

The above (Formula 2-13) has no physical meaning, so we won't discuss it for the time being.

Available from (Formula 2-14)：

$$T \approx \frac{h\nu_{max}}{2.82143937\,k} \quad \text{(Formula 2-15)}$$

Put Planck constant h＝6.6260695729 × 10^{-34} J·s And Boltzmann constant k＝1.380650524 × 10^{-23} J/K Substitute the above formula to get:

$$T \approx \frac{h\nu_{max}}{2.82143937\,k} = 1.700989 \times 10^{-11}\nu_{max} \quad \text{(Formula 2-15')}$$

According to (Formula 2-15'), the temperature of a blackbody is directly proportional to the value of the frequency ν_{max} corresponding to the maximum radiation intensity. At the same time, it shows that when the temperature tends to 0, the blackbody radiation should also tend to 0. Therefore, in a vacuum without any physical substance, even if there is an electromagnetic field and a gravitational field, its temperature is zero and its radiation should be zero.

D, calculation of solar surface temperature

The wavelength of the peak in the solar spectral parameter distribution curve is 0.5 μ m and the frequency is 6.0x10^{14}Hz, which can be obtained by substituting (Formula 2-15')：

T_{Sun}＝1. 700989×10^{-11}×6. 0×10^{14}＝10205. 93（K）＝9932. 78（℃）

According to Wien's law: T=b/ λ_{max}, there are：

T_{Sun}=2. 898×10^{-3}/(0. 5$10^{6}$)=5796（K）＝5522. 85（℃）

The results of the above two kinds of calculation of solar surface temperature are quite different. However, according to the difference between Wien's law and Planck's blackbody radiation formula and the experimental observation data, the credibility of the latter should be much less than that of the former. From this, it can be concluded that the commonly used data of solar surface temperature of 5500 ~ 6000℃ at present should have a great deviation from the actual surface temperature of the sun, unless Planck's blackbody radiation formula has no correlation with the observed data of solar surface radiation energy spectrum.

2.3.4, The true meaning of heat

Heat is a measure of the energy transferred from a high-temperature object to a low-temperature object due to thermal motion, but it is essentially the change of the motion speed of molecules or atoms in an object, that is, the motion speed of atoms or molecules in a high-temperature object is high, while that of atoms or molecules in a low-temperature object is low, and the motion speed includes thermal motion (disorderly motion), directional motion, resonant motion and so on. Therefore, heat is essentially a process in which an atom or molecule with a high speed collides with an atom or molecule with a low speed, and the speed of the two atoms or molecules is exchanged or the speed is slowed down while the speed is slowed down. From the point of view of energy, it is a process in which atoms or molecules with high kinetic energy transfer part of their kinetic energy to atoms or molecules with low kinetic energy, so that their kinetic energy is reduced, while the collided low-energy atoms or kinetic energy of molecules are improved. When thermal equilibrium is reached, that is, the kinetic energy or velocity of atoms or molecules converge.

3. Explanation of abnormal relationship between temperature and heat when water changes between different states

As we discussed above, when water changes between different states, such as ice into water or water into ice, water into gas or gas into water, its temperature remains unchanged, but it will absorb or release a lot of heat. According to the general laws of physics: when absorbing heat, the temperature of an object will rise, and vice versa. Then why is it that when ice becomes water and water becomes gas, although ice at 0℃ absorbs heat and melts into water, the temperature of water is still 0℃? Similarly, water at 100℃ absorbs heat and evaporates into water vapor at 100℃. This abnormal situation can be explained by the above essential meanings of temperature and heat: ice or water with the same temperature of 0℃ and water or steam with the same temperature of 100℃ have the same main radiation frequency (the frequency corresponding to the radiation peak) because the average speed of thermal movement of water molecules inside them is different. That is to say, whether it is ice or water at 0℃, its radiation frequency is basically unchanged, so the temperature is also unchanged. However, because ice is solid, the average speed of molecular thermal motion is much less than that of molecules in liquid water, so its kinetic energy is much less than that of molecules in liquid water. Only external energy can make the molecules in solid ice gain enough kinetic energy to become liquid water. Similarly, the same is true when water at 100℃ changes into steam.

4. Explanation of abnormal temperature of solar photosphere and corona

The temperature of the photosphere on the surface of the sun is about 6000°C, while the temperature of the corona can reach 1-2 million C.. This is different from the general physical laws, and why is the temperature difference so great? At present, there is no ideal explanation method. In fact, this anomaly can be well explained by applying the essential meaning of temperature and heat: First, the influence of density difference: the photosphere is a gaseous plasma, but its density is much higher than that of the corona layer. Therefore, the particles in the plasma in the photosphere are easily influenced by other particles around them during the thermal motion, which makes their motion speed much slower than that in the corona layer. Second, the influence of the distance difference between ions: when the photosphere is in the plasma state, the positively charged ions and negatively charged ions move in opposite directions under the action of electromagnetic field, which is easy to collide with each other and slow down the movement speed, and at the same time, the electromagnetic radiation is mostly cancelled out. Only the radiation that has not been cancelled out can be transferred out of the photosphere to chromosphere and the corona layer and then reach the earth. Although the corona layer is also in the state of gaseous ions, it is quite different from plasma because of its low density, and the chance of ions colliding with each other is much smaller than that of the photosphere. Therefore, after being accelerated by the sun's own electromagnetic field, the speed of various ions can reach a fairly high speed, and the electromagnetic radiation generated by them is not easy to cancel each other out, and it is easier to reach the earth and be observed by people. The third is the influence of electromagnetic environment: the electromagnetic environment of the photosphere should be very different from that of the corona layer. Because the photosphere is in a plasma state, it is generally in an electrically neutral state. When a changing electromagnetic field is applied externally, charged particles will rearrange outside the photosphere to form an electromagnetic shielding layer, so that the externally changing electromagnetic field cannot be transmitted to the deep inside. Therefore, the main frequency of electromagnetic radiation in the photosphere will not be affected by external electromagnetic fields. However, due to the low ion density in the corona layer, the external electromagnetic action is easily transmitted to the whole corona layer.

In a word, the difference in thermal velocity and average resonance frequency of ions due to the differences in density, ion spacing and electromagnetic environment between the photosphere and the corona layer is the fundamental reason for the temperature anomaly. That is, the thermal motion speed of ions in the photosphere is small and the average resonance frequency is low, so the temperature is low; However, the temperature in the corona layer is high because of its high thermal motion speed and high average resonance frequency.

5, The heat balance of anomaly interpretation object

Generally, the surface temperature of the earth satellite is about 200℃ on the light side and -200℃ on the non-light side. Even if the satellite is exposed to sunlight for a long time, the surface temperature of the satellite cannot reach a constant temperature. That is, it is impossible for a satellite exposed to the sun for a long time to reach a constant surface temperature, even if the surface of the satellite is made of materials with good thermal conductivity. According to the general physical law: when a heat conductor is heated at one end, the temperature of the heat conductor will be constant as long as it is heated for enough time. In fact, general thermal insulation materials will achieve constant temperature after long-term heating, unless their heat dissipation conditions are better than their heat conduction capacity. Therefore, when the satellite is in outer space near vacuum, the temperature of the satellite surface will rise after absorbing sunlight, and the surface material will transfer heat to other parts, including the back surface. Because the satellite is in a near vacuum state, it is impossible for the satellite to conduct heat to other objects. Therefore, only thermal radiation can radiate the solar energy absorbed by satellites in the form of electromagnetic waves. When the total amount of electromagnetic radiation energy of the satellite is equal to the absorbed solar energy, the thermal balance is reached. However, this balance is dynamic, and the temperature of the satellite surface does not reach the same temperature of all parts. That is to say, there are temperature gradients and molecular thermal motion velocity gradients on the satellite surface. It can be seen that when the whole object is not uniformly heated or the heat dissipation conditions of each part are different, there will be temperature difference inside the object. The reason why the temperature of the satellite surface exposed to sunlight for a long time will not be constant is that the heat dissipation and heating conditions of different parts are different, and the temperature gradient or thermal motion velocity gradient is allowed in the sanitary surface material.

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Due to my lack of English ability, the Chinese to English translation was achieved through common software. Therefore, the English version is likely to have more inaccurate and not easily understood parts. In order to facilitate the review of the manuscript by experts, the original Chinese version is attached. Please accept my apologies for any inconvenience.

温度和热量及能量的本质初探

作者：彭晓韬

日期：2023.06.23

［文章摘要］：本人通过对温度和热量的本质进行剖析发现：温度不是分子热运动平均动能的标志，而是与热辐射强度峰值对应的频率相关，温度与分子热运动主频正相关。基于此可很好地解释多数物质相变期间温度不变但会吸收或释放大量热量等物理现象。同时预测并解释了多数固体材料的比重与比热成反比关系等物理现象。热量是分子的温度趋同过程中，分子的动能变化程度的量度。本文拟在对温度和热量有了新的认识基础上，对熵增、热寂和热力学第二定律进行重新解读和认识。

能量是物理学中最常见的专用名词，但对能量的本质的认识仍然存在诸多争议和误区。本文拟对能量的本质进行深入的探讨，并在此基础上阐述其物理意义。同时，利用对温度和热量本质含义的阐述，应用到对水相变时的温度与热量相关性异常和太阳外部各层温度分布异常进行了的解释。

在重新审视普朗克黑体辐射公式二种形式（频率、波长分别与能量强度的关系式）的差异基础上，重新推导了黑体温度与辐射强度峰值所对应的频率间的关系式，并利用此关系式计算了太阳表面的温度为9932.78℃，而不是维恩定律计算的5522.85℃。还对人造地球卫星表面温度不均匀的原因进行了探讨。

第一章
如何认识和解读熵增及热力学第二定律

一、温度和热量的定义

1、温度的定义

温度是表示物体冷热程度的物理量，微观上来讲是物体分子热运动的剧烈程度。温度只能通过物体随温度变化的某些特性来间接测量，而用来量度物体温度数值的标尺叫温标。

从分子运动论观点看，温度是物体分子运动平均动能的标志。温度是大量分子热运动的集体表现，含有统计意义。对于个别分子来说，温度是没有意义的［摘自厚度百科］。

2、热量的定义

热量是指当系统状态的改变来源于热学平衡条件的破坏，也即来源于系统与外界间存在温度差时，我们就称系统与外界间存在热学相互作用。作用的结果有能量从高温物体传递给低温物体，这时所传递的能量称为热量［摘自厚度百科］。

二、温度和热量的真实含义

1、温度的真实含义

根据普朗克黑体辐射公式

$$E=\frac{8\pi h\nu^3}{C^3}\frac{1}{e^{\frac{h\nu}{kT}}-1} \qquad \text{（公式一）}$$

可知：辐射强度 E 的最大值对应的频率 ν_m 与物体的温度 T 存在密切的相关。我们可以对（公式一）对 ν 求导，并令导数等于 0。则有：

$$\frac{8\pi h}{C^3}\left(\frac{3\nu_m^2}{e^{\frac{h\nu_m}{kT}}-1}-\frac{h\nu_m^3 e^{\frac{h\nu_m}{kT}}}{kT(e^{\frac{h\nu_m}{kT}}-1)^2}\right)=0 \qquad \text{（公式二）}$$

对（公式二）两边除以常数及相同项，并简化可得：

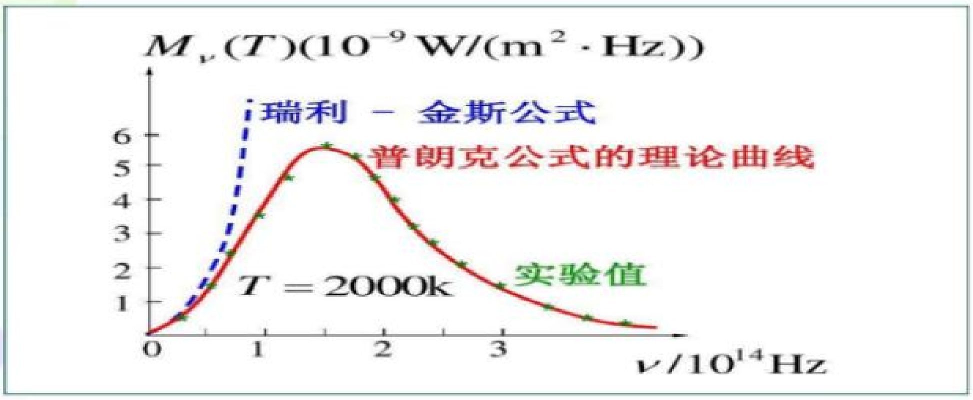
$$(3-\frac{h\nu_m}{kT})e^{\frac{h\nu_m}{kT}}-3=0$$

（公式三）

由（公式三）可建立物体温度与辐射能量峰值所对应的频率间的关系式：$T=f(\nu_m)$

$$T=\frac{h\nu_m}{2.821439372k}=0.354429023\frac{h\nu_m}{k}$$ （公式四）

如下图一所示：因为普朗克黑体辐射公式对一般物体的热辐射基本都适用，包括太阳辐射谱也基本上符合该公式。因此，物体的温度与物体热辐射谱峰值对应的频率相关的规律是存在普遍性的，可应用到一般物理研究中去。由此可见：**物体的温度不是由其分子的平均动能决定的，而是由热辐射峰值对应的频率决定的**。而黑体辐射谱的峰值频率仅与占主导地位的分子之热运动频率（以下简称“分子热运动主频”）相关，与分子的质量大小和热运动平均速度、动量和动能无关（这也是普朗克黑体辐射公式与材料类别无关的原因所在）。因此，我们有理由这样理解：温度仅与黑体辐射谱的峰值频率相关，而峰值频率仅与分子热运动主频相关。因此有：**温度仅与分子热运动主频有关**。由此可见：**温度并非与分子的动能成正比，即不是分子平均动能的标志，而是分子热运动主频的标志。**



图一：黑体辐射强度与频率关系的理论与实验数据对照图

2、热量的真实含义

热量是不同温度的物质接触或通过电磁辐射相互作用时，高温物体会使低温物体升温，同时使自己降温，在此过程中产生能量交换的数量称作热量。但从上述对温度含义的重新认识会发现：温度仅与分子的热运动主频相关。因此，若高温物体向低温物体输送热量的话，应该是高温物体分子使低温物体分子的热运动频率提高，同时使自身的频率下降以达到频率同步、温度相等。由此可见：**无论是热传导还是热辐射，热量都是由分子热运动频率高的向低的传递，并在频率相等后达到温度相同**。

3、温度与热量的关系

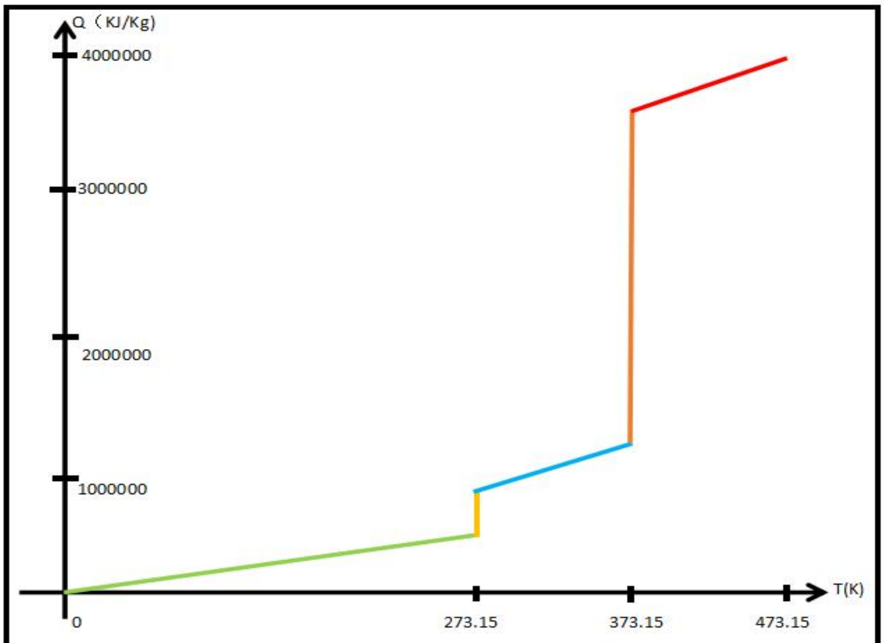
为了说明温度与热量的关系，我们选择水作为研究对象进行详细的分析：

水的比热变化简表 表一

序号	名　称	状　态	单位	热量（J）
1	0℃以下的冰每上升1℃	固　体	Kg	2060
2	0℃的冰成0℃的水	固液混合	Kg	335000
3	0~100℃的水每上升1℃	液　体	Kg	4219
4	100℃的水成100℃水蒸气	气液混合	Kg	2258000
5	100℃以上的水蒸气每上升1℃	气　体	Kg	>4221且随温度上升而增大

水的热量计算表　　表二

温度(K)	比热（KJ/Kg·K）	热量（KJ/Kg）	物态	备注
0	2060	0	冰	忽略在物态不变时的比热随温度变化的影响
273.15		562689		
	4219	897689	水	
373.15		1319589		
	4221	3577589	气	
473.15		3999689		



图二：水的内能（热容量）与温度关系图

由表一、表二和图二可知：水的温度与其所携带的热量并非简单的线性关系。在水由固体变为液体或由液体变为气体时，热量与温度间的关系为多值关系。因此，并不能直接用温度来表示同一物质热量的高低！必须考虑物质的状态，也就是分子或原子的运动状态及相互间关系。物体的温度高低虽然与其分子热运动主频正相关，也与分子热运动平均速度、动量和动能正相关但非单值函数关系。同样温度的水和冰或水和水蒸气混合物的分子热运动平均速度、动量和动能可以有很多个值。

三、支持温度为分子热运动主频标志的事实

1、物质相变期间温度与热量的关系

多数物质在相变期间，温度保持不变但会吸收或释放大量的热量。这与温度是分子热运动动能的标志不符。如：冰变为水或水变为水蒸气过程中，温度为 0℃或 100℃，但会吸收大量热量。热量的增加并未使温度上升的现象表明：温度与分子平均动能无线性或正比关系，如上表一、二和图二所示：

利用温度是分子热运动主频的标志就很好解释以上现象：作为固体的冰，其分子间距小、自由运动困难、热运动行程小；而水分子间距大、自由运动相对容易、热运动行程大；水蒸气分子间距更大，自由运动更易、热运动行程也更大。因此，在热运动频率不变的情况下，冰的分子动能最小、水次之、水蒸气最大。因此，0℃冰变成 0℃的水时，分子动能大幅度增加，自然需要吸收大量热量。100℃的水变成 100℃的水蒸气也一样且吸收的热量远大于冰变水。

2、主要金属比重与比热关系

按照温度仅与分子热运动主频正相关可以推测：物质的比热与比重呈现反比关系（分子间

距越小，热运动自由度和行程越小，所需热量也就越少）；而与单位体积内的原子数量呈正比关系。从下表二可知：比重与比热的积在 1.47～3.47J/cm³*℃间；除铝偏差大外，其余金属的比热与单位体积原子数之比在 1.325～3.264 间，表现出了一定的规律性。

主要金属的比重、比热和相对原子量及相互关系一览表 表二

名称	银	铝	铁/钢	铜	汞	铅	锌	金	备注
比重(g/cm3)	10.49	2.7	7.87	8.89	13.6	11.34	7.14	19.32	
比热(J/g*℃)	0.24	0.88	0.46	0.39	0.14	0.13	0.39	0.13	
比重*比热 (J/cm3*℃)	2.52	2.38	3.62	3.47	1.90	1.47	2.78	2.51	
相对原子量	107.87	26.98	55.845	63.546	200.59	207.2	65.39	196.97	
单位体积原子数（比重/相对原子量）	0.10	0.10	0.14	0.14	0.07	0.05	0.11	0.10	
比热/单位体积原子数	2.468	8.793	3.264	2.788	2.065	2.375	3.572	1.325	

3、电磁炉和微波炉热效率高

微波炉与电磁炉热效率一般在 80%以上，其主要原因就是因为其产生的交变电磁场的频率正好处于水分子吸收系数大的频段，水分子频率更容易被提高到与加热的电磁场频率相近。使由电能产生的交变电磁场能充分地发挥对加热物中水分子的升温作用。同时，减少了不同频率间的相互干扰与相互抵消作用而浪费的能量。

4、人流群体效应预示热平衡状态下分子热运动频率只能同步

当巨大人流行走在一条宽度有限的通道内时，相互间同步才是效率最高的通行方式。同理，处于热平衡状态时，物质中分子的热运动频率也必须相同，这样才会使系统稳定且不相互碰撞而发生能量转移而失衡。

5、半导体制冷（热）原理

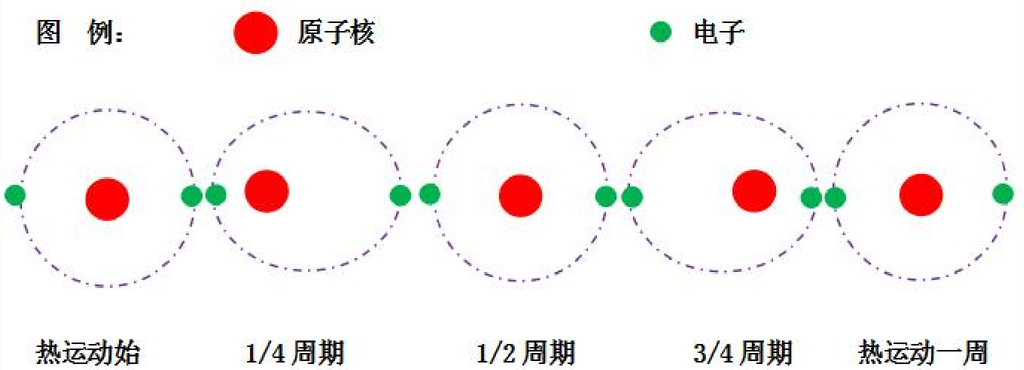
当由两种（N 和 P 型）半导体构成的制冷片通电后，电子由一端向另一端移动时，电子移出端因补充来的电子振动频率低于原来的电子，而使此端降温；而通过 PN 结运动到另一端的电子被电场加速后，振动频率提高使该端温度升高。这就是半导体制冷（热）的基本原理。

6、压缩方式制冷（热）原理

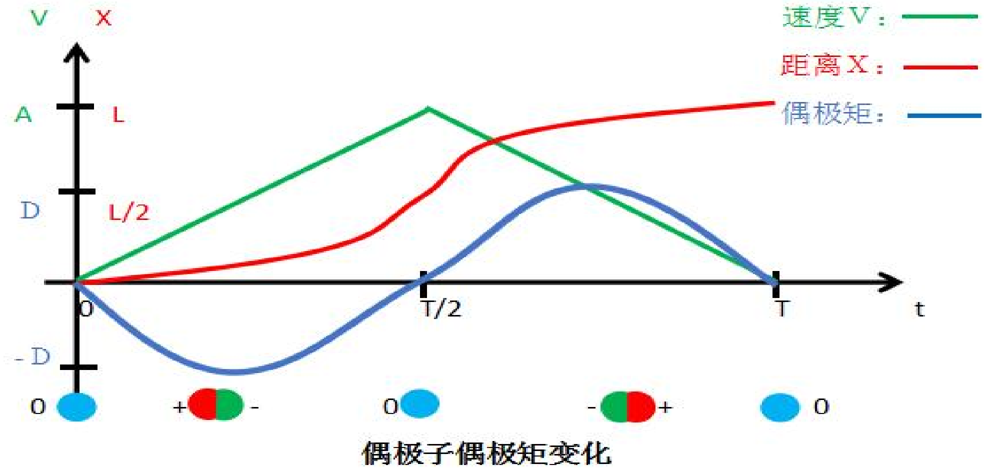
当气体被压缩时，由于分子间距减小，热运动频率自然上升而升温。而当减压时，分子间距突然增大而行程加大，热运动频率自然下降而降温。这期间均有外来热量交换但温度发生剧变的原因就是分子热运动行程的变化而导致热运动主频和温度的变化。

三、热辐射频率和电磁场强迫加热与分子热运动频率间的关系分析

1、热辐射频率与分子热运动频率间的关系



图三：原子热运动期间受力分析示意图

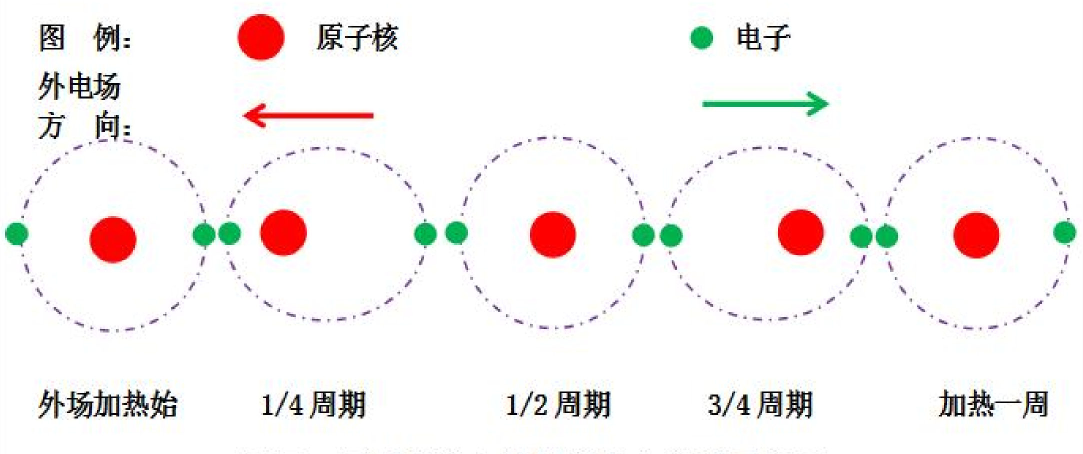


图四：热运动一周期内原子速度及移动距离示意图

分子热运动过程中，特定分子受到周围临近分子的冲撞而改变运动状态并变加速直线运动，直到另一侧其他分子阻碍而发生变减速直线运动直至暂时停止运动，此过程即为分子热运动的一个周期。而分子中的原子在此期间的受力如上图三所示：受冲撞初期，电子最先受力并改变运动状态，电子运动状态的改变迫使原子核发生运动状态的改变。此期间会使原子成为一电偶极子。当运动一定距离后，电子与原子核的运动速度同步时，原子又恢复到了电中性状态；再运动一段距离后会受到另一侧临近分子的阻碍而发生减速运动。如开始正好相反，电子最先开始减速运动并迫使原子核也进入减速运动，此过程中原子又成为一电偶极子，但极性与前面正好相反。直到原子暂时停止运动时，原子又恢复到中性状态。因此，分子一个周期的热运动会使其中的原子两次成为电偶极子，也就会向外辐射两次电偶极子电磁场，也正好完成一个周期的电磁辐射，即热运动频率与辐射频率相等。详见上图四所示。

2、电磁场强迫加热与分子热运动频率的关系

当外部变化的电磁场作用于物质时，其中的分子中的原子将受到额外的、变化的电磁场影响而改变运动方式和状态。由于原子中的原子核和电子所携带的电荷异性且质量差异巨大，因此，在同样的外部变化电磁场的作用下，两者运动状态的改变方向相反、改变的幅度差异明显：如下图五所示：外部变化电场的上半周将使电子与原子核彼此远离而形成电偶极子；下半周又使原子形成极性相反的电偶极子。其变化规律与分子热运动情形完成相同。当原子在外部变化电场的强迫下，电子和原子核最终将与外部电磁场频率同步，至此就达到了加热的目的。



图五：原子强迫加热期间受力分析示意图

四、熵增和热力学第二定律的真实含义

1、熵增定律的真实含义

1.1、熵增定律：熵增定律是指热量从高温物体流向低温物体是不可逆的。它表明世界将变得越来越没有秩序，越来越混乱。

1.2、真实含义：根据温度与分子热运动主频正正相关，则高温物体流向低温物体的所谓热量只是分子或原子热运动频率的改变而导致其动能的变化。即高温物体与低温物体发生热交换的真实情景是：高温物体分子的部分动能传递给了低温物体分子，使低温物体的温度上升，高温物体的温度下降。当两者达到分子运动频率同步时，则动能不再发生交换。对于物质成分和物态相同的物体而言，两者达到温度平衡后，分子的热运动频率相等，动量和动能也就相等了；但对于物质成分或物态不同的物体而言，两者达到温度平衡后，分子的热运动频率虽然相等了，但动能则不一定相等。如：冰水混合物，虽然温度都为摄氏 0℃，但冰的分子热运动平均行程、速度、动量和动能均远小于水分子。

物体间产生温度趋同效应过程中的热量传递方向虽然是从高温到低温且不可逆，但并不表示世界将变得越来越没有秩序和混乱。因为此过程存在二种方式：**一是固体类物体间仅表面接触热传导或液体和气体类物质间非接触式的热辐射交换热量时，因不存在物体间分子或原子的混同过程，只是分子和原子热运动频率趋同的过程，秩序不但未发生混乱，反而因相互同步的分子热运动而变得更有秩序了；二是液体和气体类物质间存在相互混合的情形时，虽然因分子的热运动会出现混同的过程，但因达到温度平衡状态时，分子的热运动频率也趋同，整体上的秩序也比混同前更好。至于说由于液体和气体的混同过程造成的混乱并非由温度的变化或热量的传递引起，而是分子热运动的必然。就算是两种温度相同的液体和气体混合也同样会出现混同的现象，但此过程并不发生热量的传递。**

2、热寂的可能性

2.1、热寂的含义：热寂是猜想宇宙终极命运的一种假说。根据热力学第二定律，作为一个“孤立”的系统，宇宙的熵会随着时间的流异而增加，由有序向无序，当宇宙的熵达到最大值时，宇宙中的其他有效能量已经全数转化为热能，所有物质温度达到热平衡。这种状态称为热寂。

2.2、可能性分析：由以上分析可知：物体间的热交换过程只是分子热运动动能的交换过程。而影响分子热运动动能变化的因素很多。如：万有引力、电磁力的作用。同时，物质的宏观运动和组成分子的原子以及组成原子的电子和原子核的非热运动动能并未考虑在热能中。就算物体处于绝对 0 度，其宏观运动仍然存在，原子中的电子及原子核也是在运动的，仍然存在巨大的非热运动动能。特别是带质量的粒子本身具备的能量与质量和光速的平方之积成正比。这部分能量也未考虑在内。最重要的是：物体特别是固体均存在温度梯度，即同一物体的表面与内部的温度并不会完全一致而达到温度相等，非金属材料比金属材料表现的更加显著。这也是为什么太空中的飞行器受太阳照射面与另一面的温度差如此之大的原因所在。也是帕克太阳探测器能如此近地靠近太阳并经受住太阳附近一千多度高温的原因所在。由于物体存在温度梯度，不同表面受到的外来电磁辐射不同时，其表面分子的热运动频率都会与外来的辐射谱峰值频率趋同。在太空中的飞行器面朝太阳一侧受阳光的作用，飞行器表面分子的热运动频率将与太阳光谱的峰值频率趋同；而另一侧因电磁辐射很弱，主要为宇宙背景辐射及飞行器散射及传导，当飞行器材料的传递效率不高时，则温度将远低于迎阳面。

通过以上分析可知：要使一个系统甚至整个宇宙达到热寂的条件相当苛刻，除非宇宙间所有物质均为液态和气体并聚集在一起。否则，总是会受到万有引力和电磁力的作用而发生运动状态的变化。这种运动状态的改变将使物质中分子的热运动状态发生变化而产生温度差异。也就永远不可能使宇宙间所有物质温度相等而出现热寂状态。

3、热力学第二定律的解读

3.1、热力学第二定律：热量在自发的情况下只能从高温物体传向低温物体。热传递的方向和温度梯度的方向相反。

3.2、真实含义：通过上述对温度和热量的分析可知：所谓热量会自发地从高温物体传递到低温物体，实质上是热运动频率高的分子与频率低的分子相遇或发生电磁相互作用时，会使两者的热运动频率趋同（这样才会使两者运动同步而不会或减少彼此干扰）。即运动频率高的下降，运动频率低的上升，直到两者频率相同为止。

综上所述，温度仅与物体的分子热运动主频正相关，而与分子热运动的平均行程、速度、动量和动能无关！热量传递的过程实质上是分子热运动频率趋同的过程。同温度条件下，分子热运动的平均速度、动量和动能与分子热运动的行程和分子的质量正相关。这些才是温度、热量及其热交换的本质因素和特征。

第二章
试论能量的本质及其意义

一、能量的定义

能量（energy）是物质的时空分布可能变化程度的度量，用来表征物理系统做功的本领。能量以多种不同的形式存在；按照物质的不同运动形式分类，能量可分为机械能、化学能、热能、电能、辐射能、核能、光能、潮汐能等。这些不同形式的能量之间可以通过物理效应或化学反应而相互转化 。各种场也具有能量。能量的本质是物理意义上四维空间度量的一个物理量，类似的还有三维空间度量的物理量--动量，以及二维空间度量的物理量--质量等等。它们都是物质在不同维度所表现出来的物质属性。

能量是物质运动转换的量度，简称“能”。世界万物是不断运动的，在物质的一切属性中，运动是最基本的属性，其他属性都是运动的具体表现。能量是表征物理系统做功的本领的量度。能量是用以衡量所有物质运动规模的统一量度[摘自《百度百科》]。

二、能量的形式

能量可分为机械能（动能和势能）、化学能、热能、电能、辐射能、核能、光能等。

7、动能

动能是物体由于作机械运动而具有的能。

$E_k = 0.5mv^2$　其中：E_k为动能、m 为质量、v 为速度

8、势能

典型的势能有重力势能、引力势能、弹性力势能。

9、化学能

物质发生化学变化（化学反应）时释放或吸收的能量。

10、电能

正负电荷之间由于电力作用所具有的（电）势能。

11、辐射能

指光和电磁波的能量。

12、核能

原子核内核子的结合能，它会在原子核裂变或聚变反应中释放出来变成反应产物的动能。

三、能量的特点

1、质量的作用

机械能（动能和势能）、核能均与物质的质量有关。

机械能包含动能和势能均与物质的质量有关，也就是说：只有具有质量的物质才可能具有动能和势能；

核能是物质中原子核发生裂变或聚变反应而致使反应产物获得巨大运动速度向核外运动而产生强大的动能。因此，也与物质的质量有关。

综上所述，带质量的物质才是能量的载体，也是能量转换和传递的媒介。

2、电荷的作用

化学能、电能、辐射能和核能均与物质的带电量，即电荷有关。

化学能是两种物质经化学反应后构成新的物质，在此过程中，两种或两种以上的元素的外

层电子发生运动方式和运动区域的变化，从而导致自身和周围其他物质运动状态的变化；

电能是物质中电子的定向运动导致其周围空间的磁场和电场发生变化，从而导致自身和周围其他物质运动状态的变化；

辐射能是物质中电子和原子核运动状态发生有规律性的变化过程中，使其周围空间的电场和磁场均随时间变化，从而导致自身和周围其他物质运动状态的变化；

在原子核发生裂变或聚变反应过程中一般也伴随着带电粒子的的产生、消亡和运动状态的巨大改变，从而导致原子核周围空间的电磁场发生巨变，从而导致自身和周围其他物质运动状态的改变。

综上所述，电荷的作用是带电物质改变其所在位置附近的电磁场，进而导致自身和周围带电体的运动状态的改变。从宏观上看，这种作用就像把带电体物质的动能转移到了附近的其他物质而发生能量交换作用。但从本质上讲，仍然是带质量的物质运动状态的改变才导致能量的传递现象的发生。电荷本身并不具备能量的基本属性和特性，也不是能量的载体。

3、运动的作用

无论动能、势能、化学能、电能、辐射能和核能均与带质量或/和带电荷物质的运动有关。

动能无疑是直接与带质量物质宏观运动有关的能量；

势能也是与带质量物质空间位置的改变从而导致自身运动趋势和能力的改变有关的能量；

化学能是带质量的物质内部微观世界的原子、分子的运动方式的改变直接相关的能量；

电能和辐射能均是带质量并带电的粒子的运动导致周围带电体所在位置的电磁场改变而致使其运动状态改变的能量；

核能是带质量的原子核发生裂变或聚变过程中，构成原子核的质子和中子等基本粒子的运动状态发生改变，从而导致能量的变化。

综上所述，当带质量的物质发生宏观或微观运动时，将导致能量的变化、转化和传递。

4、参照系的作用

凡是与运动速度和空间位置有关的能量，如动能、势能、化学能、电能、辐射能和核能的量值均与参照系有关。同一物质在不同的参照系中的同一时刻所具有的能量值是不相同的。如：在某一参照系中相对静止的物体，其动能为 0；而在另一相对此参照系作匀速直线运动的参照系中，该物体的动能就不为 0。

四、能量的本质

从以上分析可知：无论是哪种能量，均与带质量和电荷的物质密不可分。再进一步细究就会发现：其实电荷在能量中的作用很有限，虽然在微观世界中电荷的作用远大于万有引力的作用。无论是万有引力使带质量的物质发生运动状态的变化而获得动能或势能的变化，或电场使带电且带质量的物质的运动状态发生变化而获得动能或势能的变化，或磁场使带磁性且带质量的物质的运动状态发生变化而获得动能或势能的变化，还是化学反应致使带质量的原子或分子结合状态发生变化而导致物质的动能或势能的变化，或核裂变/聚变反应使带质量的原子核的结构发生变化而导致物质的动能或势能的变化等，其最关健的要素是物质必须带有质量才能有动能和势能的变化。**因此，能量的本质是带质量物质维持及改变运动状态和空间位置能力的量度。也就是说：没有质量就没有能量。只有有质量的物质才是能量的载体，也才能成为能量传递与转换的载体。**

五、能量的再认识

由以上论述可知：**能量必须由带质量的客观实体承载并在带质量的物质间相互传递。同时，能量的传递往往是运动速度大的物质把动能传递给运动速度小的物质，并使两者能量趋同的过程**。如：高温物质使低温物质温度上升同时使自身的温度降低的过程，就是高温物质的原子或分子的运动速度大于低温物质原子或分子的运动速度，当使高温物质的分子或原子与低温物质

的原子或分子发生直接接触时，就会形成弹性碰撞类的作用，使速度低的分子或原子速度上升，同时使速度高的原子或分子速度下降。如果两种物质非直接接触且两者间没有中间媒介（真空）时，高温物质发出的电磁波比低温物质发出的电磁波频率更高，高频率的电磁波将使低温物质的原子或分子的振动频率上升，而低温物质发出的低频率的电磁波将使高温物质的原子或分子的振动频率下降。双方相互作用的结果将达到一个平衡状态——温度趋于相等，也就是两者的电磁波的频率也趋于相同。这就是高温物质把热量传递给低温物质并使温度趋同的过程，但其中的**热量并不是一种粒子**，热量只是物质中原子或分子的热运动大小的量度，也是物质动量的一种表述形式而已。又如：宏观物体间的碰撞，运动的速度快的物体与运动速度慢的或静止的物体碰撞以及两相向运动的物体碰撞时，无论是完全弹性碰撞还是非完全弹性碰撞，总是运动速度大的物体使运动速度小的物体的运动速度提高，而自身的速度降低或停止运动或反向运动。

由以上分析，我们可总结出如下几个能量的要点：

1、一切能量的载体必须是带有质量的物质，不带质量的物质不能成为能量的载体。

2、能量的传递均是由运动速度大的能量载体传递给运动速度小的能量载体。

3、能量转换实质上是物质内部结构与运动方式的重组过程。

六、对能量认识的几个常见错误

1、纯能量说的错误

1.1、暗能量说：有一种观点认为：宇宙的总质量(100%)≌（重子+轻子）(4.4%)+热暗物质(≤2%)+冷暗物质(≈20%)+暗能量(≈74%)。其中的暗物质为不能与电磁场发生相互作用但能与万有引力发生作用的物质；而暗能量则为即不能与电磁场发生相互作用也不能与万有引力发生相互作用的物质，但也具有质量。我们知道：**具有质量的物质的基本特性有二：一是具有惯性作用能力，即在无外部作用力或外部作用力总和为 0 时，能保持自身运动状态不变的能力；二是具有万有引力作用的能力。但暗能量是不产生万有引力而是产生万有斥力，使宇宙发生膨胀而不是收缩的作用。而目前天文观测得到的天体红移量与到地球的距离成正比的结果被错误地解读为宇宙膨胀或加速膨胀的依据明显存在错误：天文观测得到的天体红移量并不是唯一地证明天体远离地球的速度与天体到地球的距离成正比（详情可参见 http://blog.163.com/pxt1961@126/blog/static/29843179201829113633640 本人的博文《揭秘河外天体红移真像的途径初探——多因素分析法在天体光谱红移中的应用》）。**

1.2、场能量说：

有一种观点：万有引力场或重力场、电磁场均为能量场且存在能量密度。也就是说：在带质量或带电物体的周围空间的任意点上均存在着万有引力能或重力能或电磁能。这种观点存在一个明显的错误：**由于万有引力和电磁力是远程力，一个点质量或电荷可在整个宇宙空间中任意空间位置上均产生万有引力或电磁力**，是否我们可以说：**一个点质量或电荷的能量分布于整个宇宙空间呢**？万有引力和电磁力均为可以进行矢量叠加的力，当两个或两个以上的点质量或电荷在同一时刻同一空间位置上的万有引力或电磁力相互抵消时，是否我们可以说：**万有引力能和电磁能可以相互抵消而消失呢？**

2、能量守恒定律的真实性

能量守恒定律（energy conservation law）即热力学第一定律是指在一个封闭（孤立）系统的总能量保持不变。其中总能量一般说来已不再只是动能与势能之和，而是静止能量（固有能量）、动能、势能三者的总量。可以表述为：一个系统的总能量的改变只能等于传入或者传出该系统的能量的多少。总能量为系统的机械能、热能及除热能以外的任何内能形式的总和。如果一个系统处于孤立环境，即不可能有能量或质量传入或传出系统。对于此情形，能量守恒定律表述为："孤立系统的总能量保持不变。"能量既不会凭空产生，也不会凭空消失，它只会从一种形式转化为另一种形式，或者从一个物体转移到其它物体，而能量的总量保持不变[摘自《百度百科》]

那么，能量守恒定律是否真的成立的呢？我们先来探讨一下单个物体的动能问题吧。

按照动能的定义：**物体的动能等于质量与速度平方乘积的一半**。那么，对于一个原子，如氢原子而言，其动能应该等于电子和原子核的总质量与其运动速度的平方乘积的一半。但问题是：**电子和原子核的运动速度有多个，甚至是无数个（相对不同的参照系而言）：**

2.1、动能因研究范畴不同而异

在不考虑原子所处空间位置的万有引力场和电磁场的情况下有：原子速度（电子和原子核构成的原子整体上在不同参照系的运动速度），**电子速度**（电子围绕原子核运动的运动速度），**原子核速度**（原子核围绕原子质心运动的速度），**质子和中子速度**（原子核内中子与质子的运动速度），**质子和中子内夸克的运动速度**（核裂变释放出α、β射线且运动速度惊人，说明在未裂变前，其运动速度并非为0，应该是在以不低于裂变后出射速度运动的（裂变过程是使其减速而不是加速的过程））等；

若考虑原子所处空间位置的万有引力场和电磁场（特别是变化的电磁场和原子周围其他原子的不断运动导致原子所在空间位置的万有引力场及电磁场随时间变化）的情况下有：在变化的万有引力和电磁力的作用下随时间变化的**整体速度、电子速度、原子核速度、原子核中质子和中子速度、构成质子和中子的夸克速度等。通常情况下**原子或分子的整体运动表现在热运动——一种看似杂乱无章的运动，物体的温度越高，热运动越剧烈。

既然一个由原子或分子构成的物体有许多种速度，那么其动能是不是也存在许多个数值呢？这应该是不言而喻的事情了。同时，同一物体在不同参照系中的运动速度也是不同的，其动能当然也就不同了。

2.2、动量和动能非标量性

由于动能与运动速度直接相关，但运动速度为矢量而非标量。因此，动能自然就为非标量了。**如：两个质量(m)相等但运动速度(v)相等但方向相反的物体发生完全弹性碰撞**时，则有：

假设碰撞后的速度为 v_1、v_2

动量守恒：$mv-mv=mv_1+mv_2$ （公式 1）

能量守恒：$0.5mv^2+0.5mv^2=0.5mv_1^2+0.5mv_2^2$ （公式 2）

据（公式 1）有：$mv_1+mv_2=0$；$v_1+v_2=0$；$v_2=-v_1$ （公式 3）

据（公式 2）有：$2v^2=v_1^2+v_2^2$； （公式 4）

将（公式 3）代入（公式 4）有：$v^2=v_1^2$ 因此有：

$v_2=-v_1=v$ （公式 5）

由（公式 5）可知：完全弹性碰撞前后的动量和动能均是守恒的。即在碰撞前和碰撞后的总动量和总能量分别为：0 和 mv^2。

我们更换一个参照系再来分析上面的案例：在相对其中的一个物体静止的参照系中，该物体运动速度为 0，而另一个运动速度为 2v（不考虑所谓相对论效应时），则上述（公式 1）～（公式 5）应修改为：

动量守恒：$2mv=mv_1+mv_2$ （公式 1′）

能量守恒：$2mv^2=0.5mv_1^2+0.5mv_2^2$ （公式 2′）

据（公式 1′）有：$v_1+v_2=2v$； $v_2=2v-v_1$ （公式 3′）

据（公式 2′）有：$2v^2=0.5v_1^2+0.5v_2^2$； （公式 4′）

将（公式 3′）代入（公式 4′）有：$v_1(v_1-2v)=0$； 因此有：

$v_1=0$、$v_2=2v$ 或 $v_2=0$、$v_1=2v$ （公式 5′）

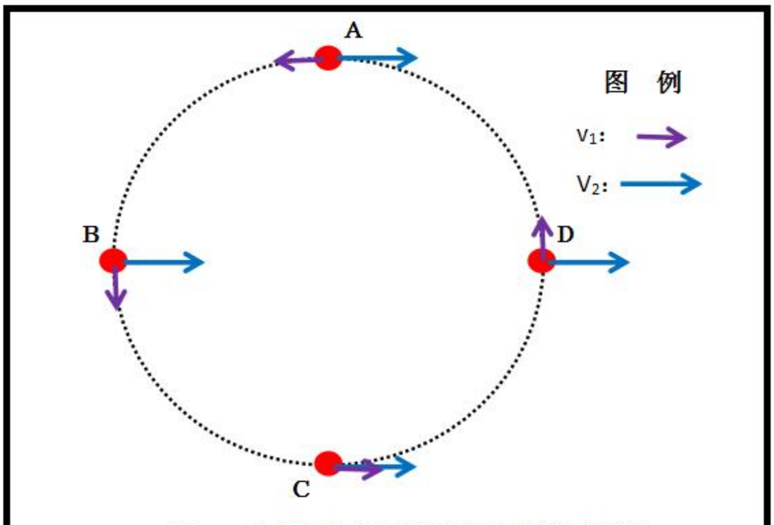
由（公式 5′）可知：完全弹性碰撞前后的动量和动能均是守恒的。即在碰撞前和碰撞后的总动量和总能量分别为：2mv 和 $2mv^2$

在相对两个相向运动的物体等速参照系中，动量总和为 0，动能总和为 mv^2；而在相对其中一个物质静止的参照系中，动量总和为 2mv，动能总和为 $2mv^2$。即总动量由 0 变为 2mv，而总能量由 mv^2 变为了 $2mv^2$。

由此可见：**同一系统的能量与动量并不是固定不变的，是与参照系相关的。**

又例如：一个质量为 m 的物体以速度 v_1 作圆周运动的同时还以速度 v_2 作匀速直线运动，如下图一所示：则为图中Ａ、Ｂ、Ｃ、Ｄ四个位置上时，其动量和动能应分别为：

A 位置时： P $=m(v_2-v_1)$　　　　　$E_k=0.5m(v_2-v_1)^2$　；
B 位置时： P $=m(v_2^2+v_1^2)^{1/2}$　　　　$E_k=0.5m(v_2^2+v_1^2)$　；
C 位置时： P $=m(v_2+v_1)$　　　　　$E_k=0.5m(v_2+v_1)^2$　；
D 位置时： P $=m(v_2^2+v_1^2)^{1/2}$　　　　$E_k=0.5m(v_2^2+v_1^2)$　；



图一：作圆周和匀速直线运动物体示意图

由以上分析可知：在作圆周运动的同时作匀速直线运动的物体，虽然其仅受到不作功的向心力的约束，但其能量仍随时间或空间位置的不同而变化。也就是：**我们不能把物体圆周运动的动量和直线运动的动能直接相加，而是要进行速度合成后再计算其动能。**

2.3、合成速度情况下的动能

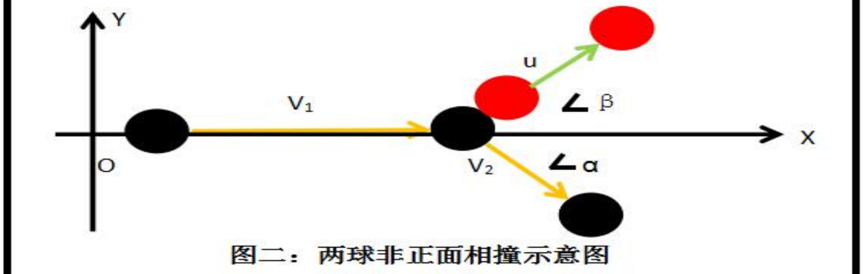
任何特定物体的运动速度的大小与方向与观察者或观测装置所在的参照系直接相关。因此，与物体运动速度直接相关的动能也与参照系直接相关。也就是说：任何特定物体的动能并不是物体本身所具有的属性，而是与观测装置与物体间的相对运动有关。

如：在运动的飞机或火车上的乘客，相对飞机或火车静止时，其动能为 0。但相对地面而言，其动能就不为 0 了，而是与飞机或火车的运动速度的平方与乘客自身体重相关了。若乘客体重为 m，飞机或火车相对地面的运动速度为 v，乘客在飞机或火车上的运动速度为 u 时，则在飞机或火车上，此乘客的动量为：$0.5mu^2$。但相对地面时，其动量则为：$0.5m(v+u)^2$。

由于观测装置相对物体的运动速度可为任意值（暂不考虑是否可大于光速 C），由此就可得出：**特定物体的运动速度就是相对观测装置的运动速度，而观测装置可以有任意多个且其相对物体的速度也有任意多个，因此，每个观测装置所测得的物体动能也不相同，也有任意多个动能值**。

2.4、动量的方向性

虽然在计算物体的动量时可以不考虑其运动方向，但物体的动量是存在方向性的，其方向与运动方向相同。所以，在桌球运动中两只桌球相撞瞬间，如果被撞击的球的质心不在与运动球的质心运动线方向上时，则被撞球与撞击球将分别向不同的方向运动。如下图二所示：



图二：两球非正面相撞示意图

假设运动球和被撞球的质量均为 m、碰撞前运动球的速度为 v_1；碰撞后运动球的速度为 v_2、被撞球的速度为 u、运动球运动方向改变角度为α、被撞球运动方向与运动球撞击前运动方向间夹角为β。则有：

A、动量为矢量时

动量守恒：水平方向：$mv_1=mv_2\cos\alpha+mu\cos\beta$ $v_1=v_2\cos\alpha+u\cos\beta$ （公式 6）

垂直方向：$0=mv_2\sin\alpha-mu\sin\beta$ $0=v_2\sin\alpha-u\sin\beta$ （公式 7）

动能守恒：$0.5mv_1^2=0.5mv_2^2+0.5mu^2$ $v_1^2=v_2^2+u^2$ （公式 8）

由（公式 7）可知：$v_2=u\sin\beta/\sin\alpha$ 代入（公式 6）可得：

$u=v_1\sin\alpha/(\sin\beta\cos\alpha+\sin\alpha\cos\beta)$ $v_2=v_1\sin\beta/(\sin\beta\cos\alpha+\sin\alpha\cos\beta)$

将 u 和 v_2 代入（公式 8）可： $tg\alpha=ctg\beta$ 进而可得：$\alpha+\beta=90^0$

当$\alpha=45^0$时，有： $\beta=45^0$ $u=v_2=v_1/2^{1/2}$

因此，**碰撞后的总动量为：$P=2mv_1/2^{1/2}\approx1.414mv_1$ 且大于碰撞前的动量 mv_1。也就是说：要确保能量守恒，就不能保证总动量守恒！只有在将动量视为矢量并进行矢量叠加与分解的条件下，才能保证碰撞前后的不同方向上的动量守恒。**

B、动量为标量时

动量守恒：$mv_1=mv_2+mu$ $v_1=v_2+u$ （公式 $6^/$）

动能守恒：$0.5mv_1^2=0.5mv_2^2+0.5mu^2$ $v_1^2=v_2^2+u^2$ （公式 $8^/$）

由（公式 $6^/$）可得： $u=v_1-v_2$ 代入（公式 $8^/$）可得：

$V_2=0$ 或 $V_2=V_1$ 则有：$u=V_1$ 或 $u=0$

因此，**在将动量视为标量而非矢量时，要使动量守恒和动能守恒同时成立，则只有在两个物体正面碰撞且运动球撞击后成为静止球，而静止球成为运动球时才能成立。而如同桌球中两球相撞时一样，撞击后两球的运动状态有无数多种，为保持动量和动能守恒，动量就不能为标量，必须为矢量。**

当将动量视为矢量时，非正面完全弹性碰撞时，碰撞前后的总动量是不相等的，一般碰撞后的总动量会大于碰撞前的总动量！

综上所述，能量守恒定律必须且只有在特定的参照系和封闭系统中以及特定的研究对象与范畴时才能成立。

2、热量与温度的真实含义

2.1、**温度：**是表示物体冷热程度的物理量，微观上来讲是物体分子热运动的剧烈程度。从分子运动论观点看，温度是物体分子运动平均动能的标志。温度是大量分子热运动的集体表现，含有统计意义。对于个别分子来说，温度是没有意义的。［摘自《百度百科》］。

2.2、**热量：**是指当系统状态的改变来源于热学平衡条件的破坏，也即来源于系统与外界间存在温度差时，我们就称系统与外界间存在热学相互作用。作用的结果有能量从高温物体传递给低温物体，这时所传递的能量称为热量。热量和功是系统状态变化中伴随发生的两种不同的能量传递形式，是不同形式能量传递的量度，它们都与状态变化的中间过程有关,因而不是系统状态的函数。［摘自《百度百科》］。

2.3、温度与热量的关系

2.3.1、水在不同状态下的温度与吸（放）热量关系

水温变化所需热量的关系表

序号	名　　称	状　　态	单位	热量（J）
1	0℃以下的冰每上升 1℃	固　　体	Kg	2060
2	0℃的冰成 0℃的水	固液混合	Kg	3350
3	0～100℃的水每上升 1℃	液　　体	Kg	4200
4	100℃的水成 100℃水蒸气	气液混合	Kg	2258000
5	100℃以上的水蒸气每上升 1℃	气　　体	Kg	4200

从上表可知：**温度与物体吸收或放出热量并不存在线性（即非单值函数）关系，主要是在物体状态变化过程中，在水由固体转变为液体或由液体转化为固体时，以及水由液体转化为气**

体或由气体转化为液体时，其吸收或放出一定的热量的过程均不会导致温度的变化。

2.3.2、近太阳太空中太阳风和物体温度

我们知道：太阳表面光球层温度大约为 6000° C，而日冕的温度可以达到 100～200 万℃。而距离太阳不同距离上的物体的温度一般均不同。如：地球附近外太空中的卫星，受太阳光照射的一侧的温度在 200℃以上，而另一侧的温度又在零下 200℃以上。而据帕克太阳探测器项目组推测：位于太阳表面 600 万千米处时，太阳光照部分的探测器表面温度在 1400℃左右。

长时间处于数十甚至上百万度的太阳风中的物体（卫星和探测器）的温度为什么始终不能与太阳风的温度相同而达到热平衡呢？

2.3.3、温度的真实含义

A、只有有形物质实体才能有温度，物质所具有的电磁、万有引力等附属特性以及真空是不存在温度的；

B、温度是一定数量的物质实体的热运动平均水平的表达，单个基本粒子或原子、分子的温度是无意义的；

C、物质辐射与温度的关系

根据物体辐射的峰值与温度的相关性，可对普朗克黑体辐射公式进行求导得到温度与辐射峰值频率的关系式：

$$E = \frac{8\pi h\nu^3}{C^3(e^{\frac{h\nu}{kT}} - 1)} \qquad \text{（公式 9）}$$

式中：E 为辐射强度；h 为普朗克常数；T 为黑体温度；ν 为辐射频率；C 为真空中的光速；k 为玻耳兹曼常数。

即：对（公式 9）求导并令其等于 0，则有：

$$\frac{dE}{d\nu}\Big|\nu_{\max} = \frac{24\pi h\nu_{\max}^2}{C^3(e^{\frac{h\nu_{\max}}{kT}} - 1)} - \frac{8\pi h\nu_{\max}^3}{C^3(e^{\frac{h\nu_{\max}}{kT}} - 1)^2} * \frac{h}{kT} * e^{\frac{h\nu_{\max}}{kT}} = 0 \qquad \text{（公式 10）}$$

整理（公式 10）可得：

$$3e^{\frac{h\nu_{\max}}{kT}} - \frac{h\nu_{\max}}{kT} * e^{\frac{h\nu_{\max}}{kT}} - 3 = 0 \qquad \text{（公式 11）}$$

令：$x = \frac{h\nu_{\max}}{kT}$ 则（公式 11）可简化为：

$$(3 - x)\, e^x - 3 = 0 \qquad \text{（公式 12）}$$

为求取上式的数值解，我们令：$f(x) = (3 - x)\, e^x - 3$ 并进行数值计算，如下表示：

由下表可知：至少有两个 x 值（x=0 和 x=2.82143937212～2.82143937213 间的某个数值）可使（公式 12）成立，因此有：

$$\frac{h\nu_{\max}}{kT} = 0 \qquad \text{（公式 13）}$$

$$\frac{h\nu_{\max}}{kT} \approx 2.82143937 \sim 2.82143938 \qquad \text{（公式 14）}$$

$f(x)=(3-x)e^x-3$ 数值计算表

x	f(x)	x	f(x)	备注
-1000	-3.00000	-700	-3.00000	
-500	-3.00000	-300	-3.00000	
-100	-3.00000	-50	-3.00000	
-10	-2.99941	-7	-2.99088	
-5	-2.94610	-4	-2.87179	
-3	-2.70128	-2	-2.32332	
-1	-1.52848	-1	-0.87714	
0	0.00000	1	1.12180	
1	2.43656	2	4.38906	
2.82	0.01983	2.83	-0.11927	
2.821	0.00606	2.8215	-0.00084	
2.82143	0.00013	2.8214	-0.00001	
2.82143937	0.00000003	2.82143938	-0.00000011	
2.82143937212	0.00000000003	2.82143937213	-0.00000000011	
3	-3.00000	4	-57.59815	
5	-299.82632	7	-4389.53263	
10	-1.54E+05	50	-2.44E+23	
100	-2.61E+45	300	-5.77E+132	
500	-6.98E+219	700	-7.07E+306	

以上的（公式 13）没有物理意义，我们暂不作讨论。

由（公式 14）可得：

$$T \approx \frac{h\nu_{\max}}{2.82143937\,k} \qquad （公式 15）$$

将普朗克常数 h＝6.6260695729×10⁻³⁴ J·s 和玻耳兹曼常数 k＝1.380650524×10⁻²³ J/K 代入上式可得：

$$T \approx \frac{h\nu_{\max}}{2.82143937\,k} = 1.700989\times10^{-11}\nu_{\max} \qquad （公式 15′）$$

由（公式 15′）可知：**黑体的温度是与其辐射强度最大值所对应的频率 $\nu_{\max}$ 的值成正比的。** 同时说明：当温度趋于 0 时，黑体辐射也应该趋于 0。因此，没有任何实体物质存在的真空中，即使是存在电磁场和万有引力场，其温度也为 0，其辐射也应该为 0。

D、太阳表面温度计算

太阳光谱参量分布曲线中峰值对应的波长为 0.5μm、频率为 6.0×10^{14}Hz；代入（公式 15′）可得：

$T_{太阳}＝1.700989\times10^{-11}\times6.0\times10^{14}＝10205.93$（K）＝9932.78（℃）

而根据维恩定律：$T=b/\lambda_{\max}$，则有：

$T_{太阳}=2.898\times10^{-3}/(0.5 10^{6})=5796$（K）＝5522.85（℃）

以上二种计算太阳表面温度的结果差距较。但从维恩定律与普朗克黑体辐射公式与实验观

测数据的吻合程度和适用范围的差异可知，后者的可信度应该远小于前者。由此可得出：**目前人们常用的太阳表面温度 5500～6000℃的数据应该与太阳的实际表面温度存在较大的偏差，除非普朗克黑体辐射公式与太阳表面辐射能谱观测数据并不存在相关性。**

2.3.4、热量的真实涵义

Ａ、热量是物质间因热运动而从高温物体向低温物体传递能量大小的量度，但本质上是物体中分子或原子的运动速度的变化，即高温物体中原子或分子的运动速度高，低温物体中原子或分子的运动速度低，而运动速度包括热运动（无序运动）和定向运动、谐振运动等。因此，热量实质上是运动速度大的原子或分子与运动速度小的原子或分子相互碰撞时，两者的速度互换或速度快的变慢、而速度慢的变快的过程。从能量角度讲，就是动能高的原子或分子将部分动能传递给动能低的原子或分子，致使自身的动能降低，而被碰撞的低能量原子或分子动能提高的过程。当达到热平衡时，也就是原子或分子的动能或运动速度趋同了；

3、水在不同状态间转换时温度与热量关系异常的解释

上面我们探讨过水在不同状态间转换时，如：冰成水或水成冰、水成气或气成水时，其温度保持不变，但会吸收或释放大量的热量。按照一般物理规律：吸收热量时物体温度会上升，反之会下降。那为什么冰成水、水成气时，虽然 0℃的冰吸收热量溶化成水，但此时水的温度仍为 0℃。同样地，100℃的水吸收热量蒸发为 100℃的水蒸气。这种异常情况可用以上对温度和热量的本质含义来解释：**同样为 0℃的冰或水，以及同样为 100℃的水或水蒸气，因其内部水分子的热运动平均速度不同但辐射主频（辐射峰值对应的频率）相同。即无论是 0℃的冰或水，其辐射主频基本不变，因此温度也不变。但因冰为固态，分子热运动的平均速度远小于液态水中的分子，因此其动能也远小于液态水中的分子。只有外来能量让固态冰中的分子获得足够的动能才能变成液态的水。同样地，100℃的水变为水蒸气的过程中也是如此。**

4、太阳光球层与日冕温度异常的解释

太阳表面光球层温度大约为 6000° C，而日冕的温度可以达到 100～200 万℃。这与一般物理规律不同，且温度差异如此之大的原因为何？目前没有比较理想的解释方法。其实，应用我们上面对温度与热量的本质含义就可以很好地解释此异常现象：**一是密度差异的影响**：光球层为气态的等离子体，但其密度远高于日冕层。因此，光球层中的等离子体中的粒子在热运动过程中易受到周边其他粒子的影响，致使其运动速度远小于日冕层。**二是离子间间距差异的影响：**光球层因处于等离子体状态，其受到电磁场的作用时，带正电的离子与带负电的离子的运动方向相反，易产生互相碰撞而降低运动速度，同时电磁辐射也多被相互抵消，只有没有被相互抵消的辐射才能传递出光球层到达色球层和日冕层后再到达地球。而日冕层虽然也为气态的离子状态，但因密度小，与等离子体太差异较大，离子的相互碰撞机会比光球层小得多。因此被太阳自身的电磁场加速后，各类离子的速度可以达到相当高的速度，且其产生的电磁辐射也不易被相互抵消，更容易到达地球并被人们观测到。**三是电磁环境的影响**：光球层的电磁环境与日冕层应该有很大差异。光球层因处于等离子态，总体上处于电中性状态，外部施加的变化的电磁场时，在光球层外部会产生带电粒子的重新排列而形成电磁屏蔽层，致使外部变化的电磁场无法传递到内部深处。因此，光球层的电磁辐射主频不会受到外部电磁场的影响。而日冕层因离子密度小，外部电磁作用很容易传递到整个日冕层。

总之，由于光球层与日冕层存在密度、离子间距和电磁环境差异而导致离子的热运动速度和平均谐振频率的差异是温度异常的根本原因。即：光球层内离子的热运动速度小、平均谐振频率低，所以温度低；而日冕层中的离子热运动速度大、平均谐振频率高，所以温度高。

5、物体的热平衡异常解释

地球人造卫星表面温度一般是：光照侧温度在 200℃左右、非光照侧温度在-200℃。即使是卫星长时间位于太阳光照射下，卫星表面的温度也不能达到恒温状态。也就是：长期暴露在阳光下的卫星也不可能达到表面恒温，即使是卫星的表层是由导热性能良好的材料制作的。按照一般物理规律：**当导热体在一端加热时，只要加热足够时间，导热体将达到温度恒定**。实际上，一般的绝热材料，在长时间办热后也会达到温度恒定，除非其散热条件好于热传导能力。因此，卫星在接近真空的外太空，卫星表面吸收太阳光后温度上升，表层材料将把热量传递到其他部

分去，包括背阳面。由于卫星处于近真空状态，卫星不可能把热量传导给其他物体。因此，只有热辐射才能把卫星吸收的太阳光能量以电磁波的形式辐射出去。当卫星的电磁波辐射能量总量与吸收的太阳光能量相等时，即达到了热平衡。但这种平衡是动态的热平衡，且卫星表面的温度并未达到各部分同温。也就是卫星表面存在温度梯度和分子热运动速度梯度。由此可见：**当物体不是整体均匀加热或各部分散热条件不同时，物体内部将存在温差**。长期置身于太阳光下的卫星表面不会出现温度恒定就是因为各部位的散热和加热条件不同，而卫生表面材料内部允许存在温度梯度或热运动速度梯度。

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