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Principles of Matter Structure: First-Principles Physics

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Abstract

This work originates in concrete curiosities about everyday phenomena the orange-red of fire, the blue of the sky, the genesis of lightning, the condensation of water vapor, and the source of magnetism and proposes a first-principles framework intended to account for such observations. The premise is a two-particles-and-three-fields scheme: protons and electrons are taken as the primary constituents of matter, each moving within its associated field, together with a temperature field that governs dynamical responses. Within this view, ordered extranuclear-electron motion exhibits a systematic dependence on temperature; the resulting changes in electron speed and organization are proposed to underlie phase transitions and other physical properties. With the exception of noble gases, atomic aggregation is attributed to valence-sharing motion: neighboring nuclei attract unsaturated valence electrons, establishing a shared circulation of these electrons around two nuclear centers ("valence-sharing rotation"), which forms structural units and builds material structure. This mechanism is advanced as an alternative to conventional descriptions invoking electron pairing and chemical bonds. The study further posits that magnetic effects are not incidental byproducts but central drivers: electron motion generates magnetic forces with right-hand-rule orientation and allows for transient retention (hysteresis), and these magnetic forces are proposed to organize metals, connect molecules, and act as dominant agents in phase changes. Attention to experimental and natural hints the co-occurrence of electric, magnetic, and wave characteristics with electron motion, and the temperature-linked variation of light color in flames is presented as evidence that electron dynamics co-generate electricity, magnetism, and radiation. The approach asserts that universal regularities require that electron motion construct material properties, and it challenges prevailing theoretical emphases (such as on quantum entanglement and string models) by prioritizing mechanistic explanations grounded in these first principles. The intended explanatory scope includes optical coloration, atmospheric and electrical phenomena, condensation, magnetism, phase transitions, and superconductivity.

Keywords: First-principles physics; Two particles; Three fields; Valence-sharing motion; Structural units; Phase transitions; Water-vapor condensation; Magnetic hysteresis; Cohesive force; Energy.

1. The First Principles of Physics

Early physical inquiry centered on tangible entities perceptible to the senses, with very limited feeling for physical fields that are not entities; in modern authoritative theories such as the electron cloud, wave–particle duality, free electrons, and particle physics their initial formulations were fanciful, nebulous conjectures on shaky ground. Yet they became entrenched and revered, costing physics the chance to explore from zero. Having lost first-principles thinking, one cannot construct first-principles physics.

1.1. First-Principles Physics (Materials Physics Orientation)

The essence of scientific research is to explore Nature's truth. Therefore, first-principles thinking deserves advocacy: start from zero, investigate the composition, motion, and outcomes of things, and accept no ready-made rules or conclusions; break the inertia of thought, find the most basic facts and the most fundamental logic of a problem; thereby, from the source, grasp the essence of the material world and explore physical reality from first principles.

In modern scientific theory: that metals conduct via free electrons guessed; chemical bonds guessed; in the photoelectric effect, that the incident light is photons guessed; the principles of superconductivity and superfluidity guessed at for decades, with conclusions still vague; the principles of phase transitions in matter guessed at for two hundred years, still ongoing. How lightning forms, why the sky is blue answered incorrectly; what the medium of light propagation is cannot be answered, revealing the innate deficiencies of modern theory. In the face of a century of scientific stagnation, physical research must broaden its vision and, by first principles, usher in sweeping innovation.

Where should the first principles of physics begin, and from what basic facts and most authentic principles should we construct first-principles physics? Some say that today's hottest theories in physics are themselves first principles. In the currently fashionable quantum theory, waves, particles, and energy are all vague; for a hundred years it has busied itself with self-justification, without major breakthroughs clearly untenable; most particles in particle physics are ghostlike how can they be first principles?

We are grateful to the scientific forebears who established the periodic table of the elements, which has stood for a century and clearly displays the composition of all elements: the Creator fashioned protons and electrons and configured their associated proton field and electron field, forming the linkage, arrangement, and motion of the two particles; adding the ambient temperature field; the primal constituents of all things in Nature are simply the two particles and three fields! This is the raw material and foundational fields of all matter, the logical core of physical thinking. All the mysteries of the material sciences will be unraveled by first-principles physics.

The periodic table records in detail the arrangement of all elements by atomic number and the periodic configuration of extranuclear electrons. Among them, the strengths, directions, and ranges of interaction between proton–proton, proton–electron, and electron–electron differ in each case; note that all interactions of the two particles are action at a distance! Acting across a distance, with both self-action and mutual action, shows that the Creator endowed each of the two particles with a different associated field, which became the source of the motion, linkage, and construction of all things.

1.2. The Association of Entity and Field: Philosophical Wisdom and a Reflection on Physics

What has led to the stagnation and confusion of modern physics? First, thought has been constrained: discussion of the ordered motion of extranuclear electrons is not permitted, making it impossible to break through on physical phenomena driven by electron motion such as phase transitions and superconductivity; second, the belief that mathematical formulas are a universal scientific key seeking to solve physical riddles by focusing solely on formulas is like climbing a tree to catch fish; third, philosophy is dull, providing insufficient effective supply to science; faced with the associated relation of particle and wave, research clings to convention, thought dares not overstep, resulting in a century of scientific torpor.

In contemporary science curricula, matter is an entity with mass; a wave is a wave each in its separate chapter. Yet in the double-slit experiment and many others, electron beams diffract, exhibiting waves; in photoelectric experiments, light waves seem to be particles. Researchers dare not conceive a unity with two manifestations, dare not imagine that the two might coexist as virtual and real; thus, they advanced the obscure doctrine that a quantum is sometimes a particle and sometimes a wave, which has awkwardly prevailed in physics for a century.

Ancient Chinese philosophy, in its sagacity, recognized that things in the world have both explicit and implicit parts; it recognized that things universally possess two kinds of connection metaphysical and physical yet present in different forms: the coexistence of Dao and qi (principle and instrument). The physical entity (qi) is associated with its field; the metaphysical Dao directly exerts important effects on the related physical entity. Modern readers may analogize with a mobile phone and its signal to envision the coexistence of instrument and principle (the phone is the instrument the signal is the principle).

Yet for a hundred years physics has neither seen nor conceived of "association" as this universal natural phenomenon. When electron beams diffract in experiments, exhibiting wave phenomena, they are baffled. They can only resort to strained explanations, saying electrons are sometimes particles and sometimes waves; or that a wave suddenly "collapses" into a particle. Because in their lexicon there is no coexistence of Dao and instrument, of metaphysical and physical; there is no wisdom of "these two arise together but are differently named."

In fact, association above and below form is the universal, real existence of natural things. Hence, in my explorations of matter, I repeatedly mention "association," because the Creator has each of the proton and electron accompanied by an associated field, causing protons to attract electrons and form atoms the beginning of all things; the motion of electrons is accompanied by electromagnetic waves, which is why electrons exhibit wave characteristics in experiments, why magnetic fields are generated and diffraction occurs… This is the physical root of the formation of all things.

1.3. Illustrative Examples of Association

The term "association," once a biological term, is in fact a philosophical category; some find it unfamiliar or abstruse. In truth, the

coexistence of instrument and principle is the most widespread, universal phenomenon under heaven; association is anything but mysterious or abrupt rather, it is commonplace and ubiquitous, touches the foundational or axiomatic basis of science, and is a basal concept of human cognition.

As humanity has entered the era of electronic communications, mobile phones and signals are in an associated relationship: people rely on physical phones and invisible waves to connect and communicate with family, friends, and the world; a person is a physical entity associated with a name and phone number; a lodestone is a solid (an atomic structure) associated with a magnetic field. Indeed, all newspapers and articles are physical paper whose content is characters, expressing news facts and intellectual connotations the field beyond the facts.

The associated-field mode of thought provides a complete logic and makes the vague wave–particle duality suddenly clear. Without the concept of "field," one cannot interpret how particles interact without contact; it is difficult to explain how electrons orbit nuclei to form atoms and molecules; without field thinking, one cannot interpret why matter protons and electrons has mass.

Modern philosophy, with naive materialism as its main body, emphasizes entities and instruments. It has made outstanding contributions to the development of modern science and industry. But it neglects the existence of "principle" (Dao), and its understanding of things remains at the level of "instrument," with physical thinking still lingering in the century-old wave–particle dichotomy. Now it has developed to the point where quantum entanglement and consciousness causality have occupied the scientific rostrum for a century. This is not because scholars are dim-witted, but because their philosophy is still immersed in the era of instruments, leaving physicists baffled about Dao and lingering, unable to part from entities.

Associated fields are universally present in natural things, yet in physics they are a new discovery. With first-principles physics, we can analyze the respective properties of protons and electrons and their interactions under their associated fields, and identify the link between the macroscopic existence of matter and the internal microscopic motion of the two particles. Through logical inference, we can probe the structural principles of matter, distill the normative principles of proton and electron structure and the consequences of their motion, and bring about spillover-style innovation.

Physics was partitioned by our scientific forebears into several branches: force, heat, light, electricity… We will likewise use first principles to examine each branch's fundamental connection to first principles, beginning with force.

2. What Is the Nature of Gravity? (Protons)

Newtonian physics and Newtonian mechanics have led human science for 300 years, yet what is the essence of force? The academic community's understanding and articulation remain unclear. Since the dawn of science, every element has an atomic weight mass; therefore, all things composed of elements possess mass and weight. This seemed self-evident, and people took it for granted, so for centuries no one investigated the essence of gravity.

Unexpectedly, in recent years the grand question "What is the essence of gravity?" has taken center stage and become a scientific frontier. Thus, eight years ago, the journal Science published the world's 125 most cutting-edge scientific questions, among which: 34. What is the essence of gravity? To this day it remains unsolved.

2.1. The posing of the gravity problem

The gravity problem was raised because, with the development of nuclear physics, explorers seeking the secrets within the nucleus used high-kinetic-energy accelerated particles to bombard atomic nuclei, and in the fragments of these collisions found dozens of microparticles, which were classified to establish particle physics. Strangely, among 63 particles, aside from the electron, proton, and neutron, all the others astonishingly had no mass! The ingrained mindset that all things possess mass was thus challenged, prompting reflection: Why do those particles have no mass? Where does mass come from? What is the essence of mass? This fundamental problem in physics was brought to the table.

In the search for mass, some scholars conjectured: perhaps the bombardment power of the particle collider was not large enough; there should be a kind of God particle (Higgs boson) that had not been found, and perhaps this God particle bestows mass upon those other particles. Hence, constructing a supercollider became the dream of particle physicists.

The proposal to build colliders sparked a great uproar for two reasons: first, the theory of how particle mass forms where mass comes from was unclear and strained; second, the financial investment would be enormous and the timeline long, warranting prudence.

In practice it has been found that protons and electrons with mass each exert attractions and are each accompanied by associated fields, and that these fields can influence the surrounding environment and matter. This could be the source of mass generation and is therefore a target worthy of attention and study.

2.2. Protons and electrons

Regarding the force between protons and electrons how do the two particles form atoms? Early explorers drew on a biological analogy, "like repels like, unlike attracts," and associated the proton with positive charge and the electron with negative charge; opposite charges attract, the proton forms the nucleus and attracts electrons to orbit to form the atom; electrons repel one another, creating the extranuclear space.

However, facts reveal:
1. Protons in proximity within the nucleus do not exhibit repulsion between like particles;
2. The universal attraction sourced in the proton does not produce repulsion; the attraction extends infinitely and cannot be screened;
3. Extranuclear electrons are attracted by protons, yet do not fall into the nucleus;
4. Electrons are found in extreme proximity to protons within the nucleus, yet coexist without incident.

The above facts are incompatible with the early conjecture of an electromagnetic-force theory between protons and electrons. Nature is simple and efficient; it would not first endow the proton with positive charge to produce a large repulsion within the nucleus, and then renege by introducing some magical mesons to cancel the repulsion.

After more than half a century, physics has not discovered mesons. The reason is: since Nature is the original creator, it can of course fashion the protons it wants. For cosmic bodies with the proton as the main constituent, there is only attraction and no repulsion. To construct the world of things, Nature's wise arrangement is one of diversity: besides making proton–proton attraction, proton–electron attraction, electron–electron repulsion (to build material space), centrifugal separation, and so on, the magnitudes, primacy, and field ranges (half-attenuation distances) of these forces each differ; they are not the simplistic positive and negative charges of conjecture.

Protons attract electrons; electrons are uniformly distributed and execute ordered orbital motion, thus forming atoms. Why would Nature also have electrons generate magnetic forces during motion, with directions following the right-hand rule, perpendicular to the direction of motion; and further more allow the magnetic field to linger briefly (magnetic hysteresis), causing electrons to deviate from their original trajectories and produce entwined orbital motion? Such intricate arrangements cannot be merely for making lodestones, can they? You will see that magnetism and magnetic force are the principal agents in the constitution of all metals, in molecular connections, and in phase transitions. Nature has already made exquisite arrangements using magnetic force for interatomic connections and molecular constitution; the conjectured electron pairing and chemical bonds are evidently not natural facts.

We can trust that wise Nature has other efficient, simple, and comprehensive arrangements endowing protons and electrons with their own associated, multifunctional, and practical fields to accomplish all tasks in the physical world.

The aforementioned proton and electron fields and magnetism are all original creations of Nature grand in scope, meticulous, and all-encompassing.

2.3. Exploring the proton field (six major properties)

Protons and electrons do not make contact yet can interact, and both possess mass. This is because protons and electrons are first-principles particles, each accompanied by a dedicated associated field carefully arranged by Nature. Those ghostly particles have no mass because Nature has not endowed them with corresponding fields.

Field: the dispersion by protons and electrons of their own information, physical properties, and specific influences into the surrounding space; an ontological existence associated with the entity; an important physical quantity arranged by Nature that can exert influence and forces from the entity to its surroundings, with directions, magnitudes, and attenuation that are harmonious and reasonable.

Nature has respectively endowed the two particles (protons and electrons) proton–proton, proton–electron, and electron–electron with interacting fields; and has endowed moving electrons with a dedicated magnetic field. These are rigid necessities for constructing all things.

Let us first discuss the field exclusive to the proton: there is no repulsion between protons; attraction is the dominant component of the proton field it attracts protons and attracts electrons, cannot be screened, and has the longest range (field range). Here, based on natural facts, we present a comprehensive understanding of the field associated with the proton as endowed by Nature and its multiple functions:
1. Quantitatively attracting electrons and balancing the electron field, leading electrons to orbit the nucleus. In nature, free-state protons have never been found to exist; electrons must inevitably orbit around them. This is the basic performance state of the proton.
2. Exerting attraction on all field particles (electrons and protons), a force that can extend beyond the atom to form the bonding force between atoms.

3. Possessing only aggregative functionality; therefore, the proton's attractive field cannot be screened and can only superpose, with the longest range.
4. Protonic attraction does not halt abruptly at the atomic boundary; the proton field has no boundary and constitutes universal gravitation; proton–proton attraction is independent of temperature.
5. The proton's attraction to electrons varies with the temperature field; therefore, the orbital speed of extranuclear electrons varies with temperature at high temperature, extranuclear electrons move faster; the proton–electron attractive force has a very short range.
6. The proton field (gravitational field) permeates cosmic space and is the propagation medium of electromagnetic waves; thus, electromagnetic waves can propagate through cosmic space. With the same medium, the speed of light is invariant, allowing us to see distant starlight; with a denser medium, the amplitude of light waves increases and the light intensity increases.

Nature's masterpiece includes not only the proton but also the electron; wise Nature would of course endow electrons with a dedicated field. A century ago, a theory borrowed the biological notion of like and unlike, leading to an impoverished electromagnetic-force theory. I will discuss the electron and the electron field in the next chapter; for now I will introduce the electron field related to the proton field and its interactions:

1. The proton field and the electron field attract in a quantitative 1:1 manner, forming the nucleus and extranuclear electrons; this proton–electron field is closely related to the temperature field at higher temperature, extranuclear electrons move faster.
2. The electron field is accompanied by an electric-field force; this electric force pushes electrons apart so that they are uniformly distributed outside the proton; the electric force decays relatively rapidly with distance, so its field range is short (sufficient only to push molecules apart to form gases).

Mutual attraction between protons constitutes the intranuclear structure the strong force; the proton field continues to attract extranuclear electrons and attracts neighboring atoms; the proton field's range is long and its attenuation slow, allowing it to extend indefinitely, beyond the atom to constitute gravity; extending to celestial bodies to become universal gravitation. These are the three natural forces that physics over the past century has relished discussing: the strong force, the electromagnetic force, and universal gravitation.

Strong force: protons at the nuclear center quantitatively attract electrons and mutually attract one another, serving as the principal force constituting intranuclear structure, also called the nuclear force. Because intranuclear distances are extremely small one millionth of an atomic radius after inverse-square scaling, the nuclear force becomes extremely large, manifesting as the strong force; the strong force is in fact the proton field force.

Electromagnetic force: the force of interaction between atoms through protons and electrons; it is the principal force constructing atoms and material structures. The proton force has no boundary; it is in fact the outward extension of the strong force, attracting neighboring atoms' valence electrons and attracting neighboring atoms, forming valence-sharing crystals (nonmetallic crystals). The forces related to the proton and electron the proton–electron force and the electromagnetic force are all short-range forces whose action on distant objects decays rapidly.

Universal gravitation: the proton field force exerts attraction on both protons and electrons, that is, it exerts attraction on all field particles; proton-field attraction can only superpose and follows an inverse-square relationship with distance; there is no so-called repulsion of like positive charges, so it cannot be canceled or screened. Celestial bodies in space are rich in vast quantities of matter, atoms, and protons; proton-field forces relay and extend without bound, forming universal gravitation.

Recognizing the associated fields of natural protons and electrons, under the action of the proton field, Nature's three forces are openly revealed. It is not hard to see that these three forces are in fact all attractions exerted by the proton field on external protons and electrons indeed, all are proton field forces; only because of inverse-square attenuation with distance do they exhibit enormous differences in magnitude, with action ranges from near too far and forces from large too small.

2.4. Where does mass come from?

Knowing that all protons and electrons are accompanied by fields, and that these fields interact to produce proton–proton and proton–electron attraction and electron–electron repulsion, these interaction forces can be measured and thereby yield mass; those particles without mass lack associated fields. Because the two particles each have fields and can mutually interact, that is real physics; those short-lived particles without fields and without interactions have no physical significance.

Atoms, by virtue of the intranuclear proton's attraction to extranuclear electrons and the outward extension of attraction, form molecules, form crystals, constitute material structures and material strength, and acquire the ability to resist external forces. All interactions between materials are the doings of the proton and electron fields; thus the primordial forces arise from the two particles, and an object's structural forces derive from the two particles; microscopic primordial forces are the source of macroscopic material structure and ordered motion.

At this point, the essence of gravity has an answer: the field associated with each proton leads to mutual attraction between protons

and to the proton's quantitative attraction of electrons, producing the aggregative force the aggregation of matter with fields namely universal gravitation; gravitation endows terrestrial materials with weight.

We now know the essence of gravity: Nature has endowed only first-principles physics' fundamental substances the two particles, protons and electrons with associated fields; and we also know the reason those microscopic particles have no mass because they lack associated fields. It is clear that mass arises from the action of the fields associated with protons and electrons themselves, not bestowed by other particles. The imagined God particle does not exist; using a supercollider to search for the Higgs boson is meaningless.

3. The Remarkable Electron

The electron is one of the two particles in first-principles physics. The periodic table is arranged in periods according to the number of extranuclear electrons, reflecting Nature's regularity and order. Elements with the same number of valence electrons form a group and have similar physicochemical properties; elements with different numbers of valence electrons have very different characteristics, showing that electrons are crucial architects of material properties. The motion of electrons is also the source of magnetic fields and magnetism, demonstrating the electron's enormous contribution to the constitution of material properties. Yet, for a century physics has called it an "electron cloud," declining to take it seriously, which has rendered scientific mysteries unsolved.

3.1. The Electron's Past

In 1897, J. J. Thomson discovered the electron in experiments the first fundamental particle found by humankind. This epoch-making discovery in physics marked a new stage in humanity's understanding of Nature.

Scientists arranged the numbers of electrons in elements in natural order and assigned them accordingly, thereby establishing the periodic table. Elements with the same number of valence electrons line up in a column; elements in the same group have the same valence and similar physicochemical properties. While admiring Nature's elegant simplicity, the enormous role of electrons in determining physical and chemical properties was established. In exploring Nature, humans have always used electrons to probe the way ahead; the electron became the battering ram that opens the door to science.

In Thomson's experiments, an electron beam striking a metal plate flashed repeatedly, establishing the particle nature of the electron. Concentric diffraction rings from an electron target "confirmed" the wave nature of electrons. Subsequently, the double-slit experiment showed interference by electron beams, leading physicists to think electrons should be waves; the photoelectric effect, in which light knocks out electrons, confirmed that light should be "photons," suggesting a wave can also be a particle. Thus, the wave–particle debate became the focus of inquiry, and the research object shifted from concrete electrons to abstract collectives of waves and particles and to discussions of their philosophical notions.

A century ago, physics regarded the electron as a particle; later it was taken to be a "quantum" that is both a particle and a wave. It did not probe deeply into such physical facts as the electron's associated electric field, magnetic field, and voltage. In the decades that followed, quantum physics added "wave–particle duality" and the "uncertainty principle," which further shackled the exploration of ordered motion of electrons. Consequently, the physics mainstream has vigorously promoted quantum mechanics with its wave–particle duality. Quantum theory has entangled itself between wave and particle for a hundred years without making headway, instead inducing a scientific lull. Therefore, we must seriously re-examine electrons from the ground up.

3.2. Exploring the Electron Field (Six Major Properties)

The periodic table tells us: in each element, the numbers of protons and electrons are exactly equal, and in particular the number of valence electrons underpins the material's properties. Electrons are always in ceaseless motion and produce various consequences of motion.

Electrons are very light, with mass 1/1836 that of a proton. Thus, the proton occupies the center while electrons orbit the core in ordered orbital motion a vivid picture of atomic constitution. The paths and speeds of extranuclear electrons are the mechanism and soul that constitute the physical properties of matter. The orbital motion of extranuclear electrons plays a vital role and is intimately tied to the physical properties of matter; it is not an inconsequential "electron cloud" that can be casually ignored.

All things in the world are in incessant motion an ultimate maxim of philosophy; ordered motion inevitably yields ordered consequences. Although the constitution of matter, chemical change, firelight, and phase transitions remain mysteries of Nature, these constitutions and changes are highly regular; therefore, they should arise from the ordered motion of more microscopic matter the ordered orbital motion of extranuclear electrons. This is a rigid logic, the foundation of material properties, and will necessarily present a framework in which particulars fall naturally into place.

However, in probing microscopic properties of matter, modern physics first lacked the means and later lacked the resolve; it became

entangled in wave–particle duality, placed blind faith in the electron cloud, and shackled the investigation of the microscopic motion of electrons. This led physics research to long evade motion in physics and to abandon natural reality; conclusions became petty and vague an indictment of modern physical inquiry.
Let us first look at the motion of extranuclear electrons.

Nature arranged for electron–electron repulsion, thereby constructing a vast physical space (occupying 99.9% of atomic volume) and producing suitable densities for all things. Electrons are the most active and vigorous agents of motion outside the nucleus and are bound to produce non-negligible consequences of motion. A century of electron-cloud theory has forbidden inquiry into electron motion and blocked access to the origins of material constitution. By shackling the exploration of electron motion and abandoning the consequences of microscopic motion and their factual basis, how could such "research" possibly crack scientific mysteries? This is a principal cause of the modern stagnation in the science of matter.

In constructing matter, Nature endowed protons and electrons with their respective associated fields. Humans long ago discovered the field associated with electrons: in a middle-school physics experiment, when electrons are introduced into an insulated metal sphere, a macroscopic electrostatic field immediately appears on the sphere's surface, and a voltage is simultaneously produced; the more charge introduced, the higher the voltage and the stronger the field effect; inside the metal sphere, electrons repel one another, charges migrate to the surface and to points, and discharge outward occurs. Why does more charge mean greater repulsion? Where does the voltage come from? These lines of physical evidence arising from the electron's associated field must be taken seriously. (Because the experiment can add or remove electrons, the term "charge" is also used.)

The previous chapter argued that protons possess a dedicated proton field; now, electrons interacting at a distance further prove that electrons themselves also carry associated fields!

Field: information, physical properties, and related effects that are associated with and radiated by a field source (a material particle) into surrounding space, exerting interactions and influences with neighboring entities within a certain range.

The facts indicate: electrons carry electric charge and are accompanied by a field repelling other electrons and attracting protons thus there exists a field that communicates with the outside. In particular, Nature makes electron motion generate a magnetic field, whose direction is perpendicular to the direction of electron motion (right-hand rule). The various properties and manifestations observed for electrons in experiments are in fact presentations of the electron's associated field acting in the constitution, motion, and change of matter.

To summarize, Nature endows the tiny electron with an associated electron field that has the following functions:

1. Electrons and protons mutually attract in a definite way, forming extranuclear electrons in orbital motion around the nucleus and thereby constituting atoms.
2. The electron field causes mutual repulsion among electrons, pushing them apart and producing a 2/8/18 even distribution outside the atomic nucleus, thereby constituting atomic space; upon gasification, valence electrons encircle the molecule in spherical motion, pushing apart distances and forming gases.
3. In a conductor, the macroscopic motion of electrons following a DC voltage wave forms an electric current, while a macroscopic magnetic field forms outside the wire (Oersted's experiment).
4. When electrons move, they simultaneously generate a magnetic field whose direction is perpendicular to the direction of motion the right-hand rule. The rotation of electrons around protons produces a magnetic field and is accompanied by magnetic hysteresis; electrons experience slight deviations in their motion within magnetic hysteresis. Nature constructed so many intricacies in electron motion, not to manufacture an electron cloud nor merely to provide humans with magnets and motors, but to use magnetism and magnetic forces to construct all metals and to form alloys.
5. Electrons radiate electromagnetic waves (emit light) when in high-speed orbital motion or when subjected to stimulated vibration; when an atom's temperature exceeds that of its surroundings, orbiting electrons undergo transitions and radiate electromagnetic waves to reduce their speeds; when the environmental temperature is high, extranuclear electrons can absorb electromagnetic waves of corresponding frequencies to increase their own orbital speed, achieving thermal radiation and thermal equilibrium. Electrons can undergo high-frequency vibration under high voltage and strong electric fields, and can also radiate electromagnetic waves (cold light).
6. The number of valence electrons determines an atom's physicochemical properties and crystal structure; the orbital speed of extranuclear electrons varies regularly with temperature higher temperature means higher extranuclear electron speed thus constituting the material's phase states, phase transitions, and the corresponding properties.

A tiny electron embodies six properties in one; its position, motion, direction, and speed are all well-regulated; it relates to force, heat, light, and electricity, and can produce tangible physical consequences. One cannot but admire Nature's exquisite craftsmanship. For a century, physics has treated extranuclear electrons as a fleeting electron cloud, has shackled inquiry into the laws of electron motion, and has ignored the electron's associated field how much natural information has thus been missed! This is why many "mysteries of Nature," such as phase transitions and superconductivity, remain unsolved.

Electrons are accompanied by electric fields; electron motion generates magnetism; electron vibration produces electromagnetic radiation these are functions endowed by Nature. The electron's associated field produces a 2, 8, 18 even distribution of electrons within atoms (also related to intranuclear structure); it can also separate atoms and molecules by a distance. When temperature rises and a liquid evaporates into a gas, the volume expands a thousandfold, intermolecular distances are pushed apart, work is done, and cars and trains are driven all are masterpieces of the properties of the electron field.

3.3. The Electron Field and Electron Forces

Having clarified the six major properties of the electron, we now outline the roles of electrons and their associated fields across various branches of physics, revealing the crucial part played by electrons in the edifice of physics and prompting a fresh appreciation for electrons that were neglected in earlier years thus appreciating Nature's meticulous arrangement.

Beyond mutual repulsion and layered even distribution among extranuclear electrons, free electrons are not mere particles either; the field associated with electrons also manifests as a field: in electrostatic experiments, an excess (or deficit) of electrons presents as a spherically radiating field this is the electron's associated electron field and produces a voltage, whose tendency is to achieve balance between electrons and protons.

In wave–particle duality experiments using electron beams (double-slit, Thomson-type experiments, etc.), the cross-section of an electron beam presents as concentric circles, displaying wave characteristics. This is because electrons themselves carry associated fields, causing mutual repulsion among electron beams; thus arise wave-like properties such as electron diffraction and interference. Using the perspective of the electron's associated field, all of the above experiments that simultaneously display both wave and particle aspects can be interpreted. Those speculative explanations of wave–particle duality and "consciousness collapse," and the like, can be brought to a close.

Nature arranged electrons not merely to match protons in number to achieve electrical balance; in conductors, electrons move directionally under applied voltage to form current; by endowing electrons with a repulsive field, Nature constructs material space; in particular, when electrons move, Nature lets a magnetic field accompany them (Oersted's experiment), thereby giving rise to a special internal interaction in matter electromagnetic force (magnetic field force). The magnetic field force associated with valence-electron rotation is the principal force by which atoms form metallic structures; it underlies the ductility of metals and is a major cause of phase transitions in matter; it is also the internal cohesive force (viscosity) by which liquids cluster. Evidently, the electron's functions are manifold and exceedingly important.

Looking solely from the perspective of force: there are two kinds of forces in the constitution of matter. One is the proton-field force (nuclear force, proton–electron force, gravitation), a force with the proton field as its main body;
The other is the electron-field force (the electron-repulsion force among electrons, the proton–electron force, and the magnetic field force generated by electron motion), with a much shorter field range (relative to proton-field forces). All such forces can have macroscopic manifestations; in essence, it is the respective associated fields of the two particles acting, not simply like-charges repelling and unlike-charges attracting.
(The electron's functions will be further explored in subsequent branch chapters.)

3.4. The Temperature of Extranuclear Electrons and Firelight

Let us now look at firelight and, within it, grasp the ordered orbital motion of extranuclear electrons. Two centuries ago, physics pioneers noted the close correlation between temperature and the color and wavelength of light from matter, and they established the famous Wien formula relating filament emission wavelength to temperature, confirming that higher material temperatures correspond to shorter wavelengths (higher frequencies) of thermal emission, and that the color of firelight varies with temperature. Unfortunately, explorers did not further investigate the physical cause of firelight formation, and overlooked the physical linkage between the frequency of firelight and the rotational speed of electrons. This is Nature displaying its own secrets: the speed of extranuclear electrons varies with temperature higher temperature, higher electron speed, higher emission frequency.

Thermal emission is electromagnetic radiation emitted by transitions of extranuclear electrons, reporting the transition motions of valence electrons. The frequency of firelight changes with temperature; lights of different colors result from transitions of electrons at different speeds. At higher temperatures, extranuclear electrons orbit faster; upon transition, the emitted light has higher frequency. This is the effect of Nature's temperature field.

Thermal emission arises from transitions of high-speed electrons: when a hot body's temperature exceeds the ambient temperature, high-speed electrons undergo transition vibrations (simultaneously reducing their speed), forming a vibrating source; they drive the proton field (the vibrating medium) to vibrate together, producing radiated electromagnetic waves while lowering the body's own temperature. Valence electrons in high-speed transitions radiate high-frequency firelight; as temperature drops, electron orbital speeds decrease; depending on the valence-electron speed at the moment of transition in a hot body, electromagnetic waves of various frequencies can be produced.

Electromagnetic waves of various frequencies propagate on Earth and in cosmic space, connecting humanity with the universe.

Besides the transitions and vibrations of extranuclear electrons at high temperatures that produce a material's thermal emission, there is also light produced by the vibrational radiation of free electrons under high voltage and electric fields. This light has very high frequency; it is not emitted by electrons orbiting a nucleus and is unrelated to temperature, so it is also called cold light (fluorescent lamps, LED lighting).

3.5. Valence Electrons and Electrical Conductivity of Matter

It is a fact that metallic conductors have good electrical conductivity. This good conductivity does not arise from any so-called free electrons, nor does simply naming something a "charge carrier" endow it with extraordinary conductive power. Leaving aside whence comes the "freedom," research should first focus on several physical details in the conduction process:
1) Before current forms, voltage is first applied to the wire (e.g., by plugging into a terminal board). At that moment, conduction has not yet occurred, but the voltage has already been transmitted to all parts of the wire.
2) A circuit must be closed to form a current (to maintain proton–electron balance, not free electrons).
3) Besides conducting electricity, metal wires can conduct communication signals; they carry medium-wave, shortwave, and signal waves electrical signals that flow smoothly into cell phones. That wires can conduct electrical signals indicates the presence within the wire of pathways for certain-frequency electromagnetic waves. Optical fibers can transmit light signals because there are internal pathways for light waves.
4) Nonmetals do not conduct electricity, first because neither voltage waves nor electrical signals can propagate within them (there are no internal pathways).

The principle of metallic conduction brings to mind water flow and logistics... Abstracting and generalizing the commonalities and essence of all circulation: (i) there is a flowing substance (water); (ii) there is a drop or driving force; (iii) there must be a pathway; (iv) circulation must close into a loop; (v) exchanges occur to approach balance. These five are the logic of circulation; all forms of circulation (finance, logistics, blood circulation) are no exceptions especially the pathway, which is crucial!

The principle of metallic conduction is likewise "circulation," and it involves six conditions: (i) the presence of valence electrons able to swap positions and move; (ii) a driving force (voltage); (iii) because metals have few valence electrons and spacious outer shells, there exist pathways for waves and electrons; (iv) once a circuit is formed, under the push of the voltage wave, a small number of valence electrons drift with the wave and circulate along the pathway, forming current; (v) throughout the entire conduction process, the equality of the numbers of protons and electrons is maintained at all times; (vi) the direction of flow trends toward balance.

The principles by which metal wires transmit electrical signals and conduct current are entirely consistent with the above details.

Metals conduct electricity smoothly and conduct electrical signals because metals have few valence electrons and relatively empty outer electron layers, thereby forming pathways for voltage waves and current. Only then can a voltage wave enter the pathway, circulate within the loop, and drive a small cohort of co-directed valence electrons to swap positions and move, forming current. Each electron in a metal corresponds one-to-one with the protons in the nucleus; the electron flow during conduction consists of those electrons in the pathway pushed along by the voltage wave the flowing medium. Mistaking the flowing medium for the pathway itself (free-electron conduction) is like claiming the automobile is the highway.

Yet for a century the free-electron theory of metallic conduction has become deeply ingrained. The above merely discloses some ideas of circulation–conduction, the conditions for circulation, and electrons driven by circulation waves, to encourage a rational view of conduction. After we discuss metallic structure later, we will further substantiate the principle of conduction.

The six major properties endowed to electrons by Nature can comprehensively interpret multiple phenomena across the branches of physics force, heat, light, electricity, and magnetism. Notably, all these interpretations are not merely self-consistent, but mutually consistent and continuously consistent a mutual coherence that scientific exploration longs for. A century ago, physics took the orbital motion of extranuclear electrons to be an electron cloud, severing any relation between electron motion and properties such as force, heat, and light; research missed alignment with natural facts, leading to erroneous results that could only be consoled by self-consistency.

Thermodynamics, electricity, magnetism, optics, and even chemistry are all closely related to the motion of extranuclear electrons. Electric fields, magnetic fields, and electromagnetic waves are all consequences of electron motion. Electrons orbiting protons constitute atoms. Many mysteries of Nature will be readily resolved as we investigate the ordered motion of electrons.

4. The Constitution of the Atom

The great scientific achievement the periodic table of the elements tells us that atoms are the most basic independent existents that constitute matter; nearly a hundred elements make up everything in the world. Elements in the same column merely share the same

number of valence electrons, and their physicochemical properties and crystal structures are basically the same. Any atom is formed by the ordered motion and conjunction of protons and electrons; as atomic mass varies, different substances are formed, each with its own properties and characteristics. Therefore, protons and electrons are the first-principles base materials that constitute all things; they are the first-principles existents of all matter.

4.1. The Base Materials of the Atom: Protons and Electrons

According to first-principles physics, protons constitute the atomic nucleus (in fact there are also electrons within the nucleus, with proton–electron microstructures, to be discussed later), and electrons become extranuclear electrons. The base materials that constitute atoms can only be protons and electrons; all material properties can only originate from protons and electrons. Thus, the foundations of the physics of matter and their corresponding mechanisms must be contained within the interrelations and motions of these protons and electrons.

Therefore, the exploration of the physics of matter must begin with an inquiry into the two particles and their associated fields; this should be the foundation of physics and, quite naturally, the handle by which we pursue physical inquiry.

Research in physics should not forget its original aspiration: rationally follow the guidance of first-principles physics, begin with protons and electrons, and investigate the principles of the constitution of matter. The mechanisms of all physical phenomena manifested by matter (structure, strength, heat transfer, electrical conduction, phase transitions, light, magnetism, etc.) can only be contained in the interactions of electrons orbiting protons; the strength and mechanical properties of matter must exist therein; the connections that build matter, all physical properties, and their inner mechanisms must necessarily be hidden within. The ordered orbital motion of electrons around protons is the fundamental image of the physics of matter and the logical basis of all physical properties; it is not an optional "electron cloud," but the stabilizing pillar that constitutes the physical properties of matter.

Nature has made meticulous arrangements for protons and electrons: extranuclear electrons are layered and uniformly distributed outside the nucleus according to 2, 8, and 18, which precisely echoes the internal nuclear structure and displays the repulsion among electrons; the stability of protons within the nucleus and the absence of mutual repulsion between like protons are natural facts. We should discard the biological thinking of "same sex" and "opposite sex," candidly accept Nature's meticulous arrangement for protons and electrons, and explore and study the construction of the atom within the real existence and motion of protons and electrons, and thereby discover the forces that constitute matter.

4.2. The Forces that Constitute the Atom

In the previous two chapters, we discussed protons and electrons separately. The constitution of matter arises from protons and electrons; the forces that constitute matter arise from the fields associated with protons and electrons. Here is a brief recap:

The electron is not a mere quantum; Nature allows the tiny electron to be accompanied by an associated field (with six attributes).

The proton does not exist as a mere positive charge; the field associated with the proton also has six attributes.

Nature's arrangement is indeed exquisite: it sets the relationship of electric quantity (count) between proton and electron at 1:1; under the interaction between the proton field and the associated electron field, the following four forces are formed between protons and electrons.

Proton-field force: A. The atomic nucleus quantitatively attracts electrons and balances their fields, causing extranuclear electrons to orbit the nucleus at high speed. This nuclear force has no boundary; it will mutually attract the valence-sharing electrons of neighboring atoms, forming valence-sharing structures between atoms and forming structural units. This force is closely related to temperature (to be discussed next).

Abbreviated: proton–electron force. (Forms the atomic nucleus, forms atoms, maintains atomic size, and is the principal force forming molecules)
B. The proton exerts attraction on all field particles (electrons and protons), so there is no repulsive force of like-proton repulsion; the proton-field force will extend without limit and form universal gravitation; gravitation is independent of temperature.

Abbreviated: strong force (forms the atomic nucleus, forms material mass, and extends outward to constitute universal gravitation)

Electron-field force: C. The electron is accompanied by an electron field, and concomitantly by a repulsive force that repels other electrons; this is the force that constitutes the spatial extent of matter, and together with force A it maintains atomic size; it is also the force that pushes apart distances to form gaseous molecules when matter vaporizes. Abbreviated: electron-repulsion force (the force that produces uniform electron distribution and forms gaseous molecules)

D. Electron motion is accompanied by a magnetic field, and concomitantly by a magnetic-field force. This is the magnetic field produced when electrons rotate around the nucleus, along with the magnetic-field force; it is the principal force of metallic structures and also gives rise to metallic ductility and metallic luster; it is also the force of gas condensation and liquid aggregation.

Abbreviated: electromagnetic force (also the force that forms metals)
Modern physics has failed to distinguish the fields respectively associated with protons and electrons, as well as the four forces presented in combination above, and instead has simply defined "the interaction between charged particles" as the electromagnetic force. With such a definition, there is only one force electromagnetic force between protons and electrons, which leads to an inability to explain where universal gravitation comes from and why like protons do not repel; it results in a confused amalgam of three forces and in the error that the electromagnetic force does not participate in the construction of matter.

Gravitation and repulsion are a pair of contradictions: if proton forces A and B (cohesive forces) are strong, the repulsion among electrons cannot extend, matter will lack electron spatial extent, and it would be a "neutron body," a "solid block"; if repulsive force C is strengthened and exceeds the cohesive force, atoms cannot form, and the material world would disintegrate and be reduced to ashes.

How difficult it is to adjust repulsive and cohesive forces precisely to an appropriate value. The wise Nature allows proton electron and mass–mass gravitation, and charge charge repulsion, each to decay with distance according to different laws and to present distinct curves: mass–mass gravitation varies inversely with the square of distance and extends without limit forming celestial gravitation; charge-charge repulsion decays very rapidly, with a very short field range S. By such meticulous arrangement, these two curves can form an intersection (equilibrium point K), thus easily resolving the balance problem. (Fig. 4-1)

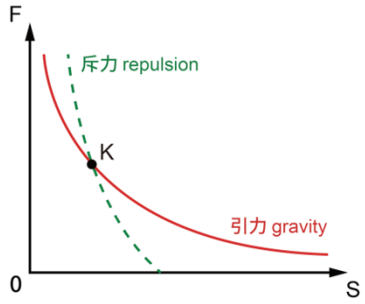


Figure 4-1. *Forces constituting an atom: F, force; S, distance. The red solid curve represents proton attraction; the green dashed curve represents electron–electron repulsion.*

A new term: force field the field of action of a force; the spatial range over which a real force acts and its decay behavior.

We have previously discussed the proton field and electron field. It is known that the magnitude of universal gravitation varies inversely with the square of the distance; this $1/r^2$ is the field-range variation of the force; proton-field force B is universal gravitation, a long-range force. However, the field range of repulsive force C between electrons is evidently much shorter, inversely proportional to the fourth power; that is, the repulsion does not propagate far and, at gas-phase intermolecular distances, it rapidly decays to extinction.

The repulsive force between electrons is not easy to measure. I used a strong magnet to measure magnetic force and its relation to distance, and found that the magnetic field force of the magnet decays rapidly, approximately inversely proportional to the fourth power of distance, i.e., $1/r^4$; at slightly larger distances, magnetism quickly disappears.

Thus, to the left of the intersection K inside the atom repulsion exceeds gravitation and dominates, opening up distances between electrons; this also leads to the layered, uniform distribution of extranuclear electrons as 2, 8, and 18; at point K, gravitation and repulsion are in balance, and the atomic radius is thereby determined, ensuring that each atom has basically the same size; to the right of the intersection, proton gravitation dominates, constituting the interatomic bonding force and universal gravitation.

Nature has constructed atoms, and the periodic table provides internal information about atoms. Research has found that, within the same period, the larger the atomic mass, the smaller the atomic radius. This fact tells us that the more protons there are in the nucleus, the greater the attraction, leading to a reduction of the entire atomic radius, indicating that the gravitational field strength of protons can be superposed and can compress electron repulsion; it also indicates that protons within the nucleus are in high-speed motion, producing uniformity of the gravitational field.

4.3. Atomic Mass and Elemental Reactivity

Electrons orbiting protons form atoms; this is the basic pattern for the existence of all things... We cannot see the characteristics and motion of these electrons, yet they can be revealed in the properties of atoms.

In middle school, our teachers required us to memorize the reactivity sequence of metallic elements: K, Na, Ca, Mg, Al... Cu, Hg, Ag, Pt, Au. We were also told that the reactive metals are those with relatively small atomic masses in the periodic table, and the unreactive ones are the heavy metals with relatively large atomic masses. This phenomenon led me to conjecture: in metals with small atomic mass, protons are few and extranuclear electrons are few; valence electrons are less tethered internally; the plasticity of orbital speed is greater, and thus they are reactive.

In contrast, for heavy metallic elements: atomic mass is large, protons are many, and extranuclear electrons are many; valence electrons are greatly constrained by the internally well-ordered moving electrons; their speeds are stable, and thus it is not easy to change the speed to react with other elements, making them appear unreactive. When approaching lighter elements, a heavy element uses its own stable valence-electron motion to alter the valence-electron motion of the light element, enabling chemical reactions that could not occur originally, thereby becoming a catalyst. It is thus evident that the reactivity or inertness of metallic elements arises from the internal factor of atomic mass that is, the number of extranuclear electrons and the magnitude of orbital inertia thus formed.

The two innermost electrons of an atom rotate spherically around the nucleus; being very close, the electrons arch apart due to mutual repulsion, so the century-old worry in physics that proton attraction would draw electrons into the nucleus is entirely groundless.

Electron–electron repulsion is the force by which matter undergoes a phase transition into the gas phase and gaseous molecules are pushed apart in distance (to be discussed under phase transitions). It is precisely because of this force that the Avogadro constant exists; and this repulsive force responsible for the expansion of gases at high temperature is also the force that propels automobiles, aircraft, and rockets.

Imagine that you were Nature, with only two particles one large and one small and temperature in your hands. You could arrange field actions to make them attract and repel, but the premise must be logical consistency. How would you orchestrate it? How would you constitute atoms and molecules? How would you build covalent crystals and metallic crystals? How would you enact phase transitions and construct the resplendent myriad things of the world? Placed in that situation, you would marvel at the wise and brilliant craftsmanship of Nature.

5. The Connection and Constitution of Matter

The foregoing discussed the constitution of atoms. How do atoms connect with each other, how do they constitute matter, how do they give rise to matter's thermal, optical, electrical, and magnetic properties, how do they realize phase transitions, and how do they form matter's specific characteristics? These are Nature's enigmas, fundamental questions of contemporary science, and the core issues of physics and chemistry.

Leaving aside gases and liquids, solids alone display a thousand forms and ten thousand properties: diamond is hard, pure gold is soft, steel has strength, conducts electricity, can be magnetized, and melts at high temperature… Where do this multitude of properties come from? All matter is constituted of atoms; how then can there be such enormous mechanical, electrical, and chemical differences? These differences are directly related to atomic connections and the constitution of matter.

5.1. The Difficult-to-Accept Chemical Bond

Since the connecting motions of protons and electrons constitute atoms and subsequently constitute matter, the various properties and internal mechanisms of matter must be directly related to the motions and connections of the two particles (protons and electrons). The constitution and relational logic of matter can only arise from the connecting motions of protons and electrons—this is the research guide provided by first-principles physics.

How do atoms connect to form matter and form crystals? Some will say, we have long known this; in middle school we already learned the various chemical bonds such as covalent bonds, ionic bonds, and metallic bonds. In addition, university courses teach mixed types among these three: degrees of ionicity; textbooks also discuss dispersion forces, induction forces, orientation forces; and σ bonds, π bonds, δ bonds…

Upon close examination, all bonding theories are at odds with Nature's axioms. In natural fact, electrons repel electrons; there is already a large body of evidence.

Experiments: When a metal sphere is charged, an electric field is immediately formed and a voltage produced, exhibiting strong mutual repulsion; in the periodic table, extranuclear electrons are layered by energy levels and distributed as 2, 8, 18, with spacing increased and distribution uniform. These experimental facts and data indicate that electrons always maximize their separations and always tend to repel.

Yet covalent-bond theory asserts that atomic connections arise from overlapping and sharing of pairs of outer electrons. Given that electrons repel, how can electrons overlap, how can they be shared, how can they "couple"? The "electron coupling" of covalent-bond

theory flatly contradicts natural facts and scientific axioms. So, do neighboring electrons repel or do they couple? A self-contradictory, back-and-forth theory is certainly not Nature's reality! The illusoriness of bond theory has brought a century of confusion to science.

The American scholar Ira N. Levine, in his book Physical Chemistry, speaks of the chemical bond with caution: "Chemists have developed a variety of empirical concepts to describe bonding; the physical reason for the stability of a covalent bond is a problem that has not been completely solved." A clear-headed scholar frankly states that the physical mechanism of the covalent bond remains unresolved, leaving room for exploration, entirely without the bravado and fearlessness of some textbooks.

Ionic and metallic bonds also do not withstand scrutiny. No one would spontaneously lose electrons first and then compete with the other side to form mutual attraction; the logic of bond theory is abnormal and runs counter to the natural properties of electrons. All postulated coupling forces formed by electron–electron chemical bond forces have no basis and directly contradict the basic property of electron–electron repulsion and the experimental facts.

The hardness of diamond and the strength of steel, their resistance to external force, indicate that a material possesses strong cohesive force. The principal force of aggregation in matter originates in protons, from the mutual attraction of proton fields and the attraction of proton fields on electrons. These two attractions should be the primary first-principles forces in material aggregation; under these basic attractions, protons attract electrons, forming the ordered orbital motion of multiple electrons around the principal force centers, achieving the constitution of atoms, the bonding of atoms, and the constitution of matter.

5.2. How Atoms Connect The Force that Forms Molecules

The title of this article is the constitution of matter. The text speaks of constituting atoms, constituting molecules, constituting… In philosophy, the commonality of this "constitution" is the organic unification of dispersed parts into a functional structural whole, which also entails necessarily existing structural modes, tendencies of combination, and combining forces.

The attraction of the proton field in the atomic nucleus for electrons is the principal force constituting atoms and the basic aggregating force constituting matter. Note: the aggregating attraction of the proton field has no boundary; a strong attraction does not abruptly cease at the edge of the atom but extends outward beyond the atom. The interatomic connection cleverly employs this basic aggregating force. As the nuclear attraction extends beyond the atom, it first encounters the valence electrons of neighboring atoms this is the first "prey" of the extended attraction. But the number ratio of protons in the nucleus to extranuclear electrons is fixed at 1:1, so the prey cannot be absorbed; neighboring atomic nuclei also have outwardly extending attraction and likewise tend to attract the other atom's valence electrons. Thus, two atomic cores mutually attract each other's valence electrons, forming shared valence-sharing electrons that orbit both atomic cores, constructing the optimal plan for atomic harmony a molecule (as in Fig. 5-1), exemplified by nitrogen and oxygen atoms forming molecules; the shared valence-sharing electrons are arranged as 2/8 or 2/8/2, inheriting the extranuclear electron arrangement pattern of 2/8/18.

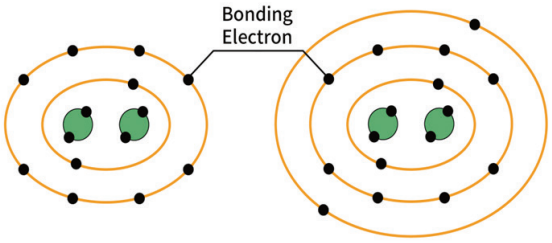


Figure 5-1. *Connection between atoms. The two solid circles at the center are atomic cores; nitrogen and oxygen molecules are shown.*

Let us probe deeper: Is the bonding of two atoms a chemical bond electron coupling or a surrounding by valence-sharing electrons?

The figure above shows two gaseous molecules. Is this truly the natural positional relation of the atomic cores and electrons in gases? Let us first look where gases are most abundant to examine their constitution and characteristics: on the right side of the periodic table, the entire column consists of inert gases. Except for helium, the hallmark of inert elements is that the periphery of every element is neatly and completely surrounded by eight valence electrons in ordered orbital motion; the outer electrons of one molecule repel those of neighboring molecules, hence pushing apart and forming gases. The facts of inert gases tell us: outer electrons (like an eggshell) execute spherical external surrounding motion to achieve repulsion, which is a necessary condition and the principle for the formation of gases.

Aside from inert gases, other gases as in the figure above diatomic gas molecules such as O_2 and N_2 can repel and float to constitute the atmosphere only if the shared valence electrons all surround the two atomic cores on the outside and are distributed as 2/8/n, like a double-yolk eggshell orbiting outside the two atomic cores; the outer electrons of one molecule repel the outer electrons of

other molecules, thereby forming gas molecules with large spatial separations.

We note that gases of the same elemental species in the atmosphere, such as hydrogen, oxygen, and nitrogen, always have two atoms firmly bonded into molecules; in chemical equations hydrogen and oxygen are also written as H_2 and O_2. At ambient temperature, these bonds appear in the gaseous state. This is a typical bond formed by sharing valence electrons, and it is the bonding form of all atoms except the inert gases; it is also the necessary condition for ordinary gases to exist.

Hydrogen gas has only two electrons; it can exist as a gas because the two electrons surround the two protons at extremely high speed. Electron motion generates a magnetic field, and under magnetic hysteresis the electrons wind and orbit at extremely high speed, forming an enclosing electron ellipsoidal surface, which leads to mutual electron repulsion between hydrogen molecules and thereby to hydrogen gas; the reason for helium's existence is likewise.

Repelling electrons cannot form coupling; electron coupling was an erroneous conjecture of earlier times. If the atoms in gases were connected by chemical bonds electron coupling unable to form outer electron surrounding, then ordinary gases could not exist.

The proton–electron combination is the principal force constituting atoms and indeed all things. The connection of atoms into molecules must employ this principal force. Nature will not backtrack and have repelling electrons couple. The mode of atomic connection is this: under central attraction, the shared valence electrons are attracted outward, surrounding the two cores to form structural units.

5.3. The Valence-Sharing Motion of Electrons Structural Units

Besides bonding to form gases, atoms more often bond to form solid crystals or liquids.
Note that, except for inert gases, no single atom can exist independently. Atoms of the same element always pair up tightly to form gases, and under low temperature can undergo phase transition to liquids or condense into solid crystals. In the condensation process, two atoms mutually attract and connect; the motion of a pair of valence electrons surrounding and orbiting two cores does not change, but only transforms from spherical surrounding to non-spherical connections. On the basis of this connection we discuss crystals and interpret how atoms bond to form crystals. (Phase transitions will be addressed in a later dedicated topic.)

In Nature there exist in great number metallic crystals, covalent crystals, and compound crystals. For atoms to constitute various crystals, the prerequisite is a cohesive force. As stated above, the attraction of atomic nuclei to electrons and to surrounding matter is the principal force for connection and for constructing crystals, the strongest and most fundamental aggregating force. This aggregating force has no boundary but extends outward beyond the atom; interatomic bonding cleverly employs this basic aggregating force.

The proton attraction of all matter extends outward mutually attracting the unstable outer electrons of neighboring atoms forming valence-electron sharing. Accordingly, the trajectories of neighboring atoms' valence electrons are as follows: under the action of two nuclei, a pair of valence electrons symmetrically surrounds the two atomic cores and orbits on elliptical trajectories. We call the motion in which valence electrons surround two atomic cores and promote the bonding of the cores the valence-sharing motion, and electrons participating in valence-sharing motion valence-sharing electrons.

The valence-sharing motion of electrons is the outward extension of the proton–electron attraction and is the important physical cause of connections in all matter. Nature's style is simplicity and efficiency: the motion of valence-sharing electrons can constitute all interatomic connections in metals, covalent bodies, compounds, and so on. The various chemical bonds supposedly formed by electron coupling simply cannot exist; Nature, in its wisdom, solves all interatomic bonding with a single valence-sharing motion, cleverly converting the proton's attraction for electrons into an interatomic aggregating force.

The outward extension of proton attraction forms valence-sharing motion and atomic bonding. Do the attractions of all protons extending outward cause confusion? No. According to the Pauli exclusion principle, only a pair of electrons can occupy the orbital that surrounds two atomic cores to execute valence-sharing motion. We call the entirety enclosed by the motion of a pair of valence-sharing electrons a structural unit (Fig. 5-2, left). The existence of structural units is simple and stable, like an atomic family; a structural unit is yet another basic tier in the units by which atoms constitute matter. The force that combines valence-sharing motion into a structural unit is called the valence-sharing force.

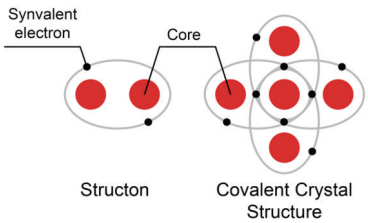


Figure 5-2. *Structural units.*

Some may say: mutual atomic connection has long existed under the name molecule what is the significance of introducing structural units?

First, the mode of connection: the connection in a structural unit is via valence-sharing electrons, a continuation of the principal force of proton attraction for electrons; whereas molecular connection is "electron-cloud" coupling, with an unclear source of force. In overall appearance, an isolated structural unit is a molecule; people have long called diatomic gases such as hydrogen and oxygen "molecules." The reason for proposing structural units is that the emphasis of structural units is foundational structure, such as metallic crystals and covalent crystals. Molecules often involve more atoms and connections between multiple structural units; for example, water and carbon dioxide are called molecules and are composed of two structural units. Methane and butane molecules are composed of even more structural units.

The great Way is supremely simple: except for inert gases, the atoms of all substances pairwise combine into structural units, and then structural units connect successively to form various crystals. In addition, noncrystalline solids, liquids, and gases are all formed by connections of structural units and then constitute molecules. Structural units are also the basic units for organic matter and living beings. All matter is formed by atoms combining into structural units, which then constitute the vast material world. See Fig. 5-3.

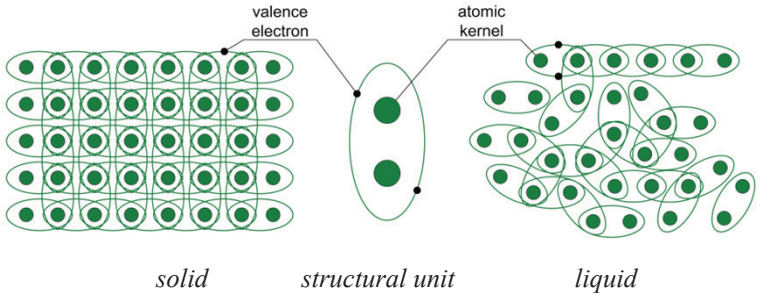


Figure 5-3. *Structural units constitute matter: solid, structural unit, and liquid configurations.*

Yet for a century physics has held that extranuclear electrons perform irregular motion as an electron cloud, making the investigation of extranuclear electrons' trajectories and speeds a forbidden zone of physics, depriving research of a genuine foothold and leading it astray.

Structural units transform the proton's attraction for electrons into the valence-sharing motion of two atoms and into the cohesive force of matter, forming atomic bonding. This is the sole source of the basic force by which atoms constitute various objects. In multivalent elements, the valence-sharing motion multiple valence electrons sequentially circulating around the cores in an orderly in-and-out indicates that the trajectories and speeds of valence electrons are orderly and regulated. Nature intends for this foundational motion to bear structural function and to build the myriad things in the world.

5.4. The Physical Cause of Crystal Formation

Covalent crystals. Because the attraction of the proton field has no boundary, it mutually attracts the valence electrons of neighboring atoms. However many valence electrons an atom itself has, it attracts the outer electrons of that many neighboring atomic cores to constitute that many structural units; the atom connects with several surrounding atoms via these structural units. Thus, structural units around a core can only be distributed uniformly at specific spatial positions so that the trajectories of valence-sharing electrons are shortest, facilitating valence-electron sharing. Innumerable cores so arranged uniformly and regularly form neat and orderly crystals.

For example, Group IV elements C, Si, and Ge have four valence electrons in the outer shell. Under proton attraction, they attract the valence electrons of four surrounding atoms to orbit in space in valence-sharing motion, constituting four structural units. All atoms of this element are each connected to four others in this repeating pattern (Fig. 5-4, left), forming the diamond-type structure of Group IV crystals. The figure shows only a basic lattice; the real body is a continuous extension of countless structural units.

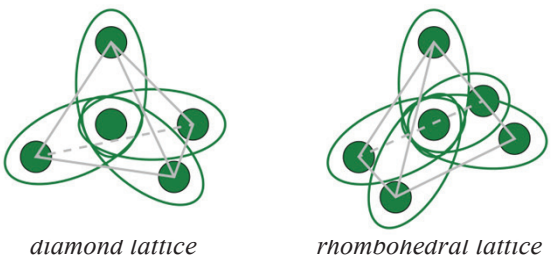


Figure 5-4. *Crystal structures: diamond lattice (left) and rhombohedral lattice (right).*

The core radius of the carbon atom is very small, and the speed of its valence-sharing electrons is very high; therefore its valence-sharing force is relatively large. With four structural units forming the diamond structure, external force can hardly damage it. Macroscopically, this manifests as diamond's very high hardness and excellent strength. Steel is produced by uniformly adding a small amount of carbon to iron, thereby increasing cohesive force and increasing strength.

Graphite is also an allotrope constituted of carbon atoms; because the structural-unit arrangement differs, we will discuss it separately elsewhere.

Similarly, Group V elements such as As and Sb each connect with five surrounding atoms in space via five structural units formed by their five valence electrons, generating a rhombohedral crystal lattice (Fig. 5-4, right).

Group VI elements Se and Te constitute a double-rhombohedral structure. An atom with six valence electrons can construct six structural units in space; hence a crystal's structure is closely related to its number of valence electrons. The neat and orderly structure of crystals is the result of extranuclear electrons running along regular, precise trajectories; the regular crystal structure provides the most authoritative interpretation of the regular orbital paths and accurate orbital speeds of extranuclear electrons.

Since electrons definitively repel each other, postulates of overlapping electron clouds and coupled chemical bonds violate this fact. Under traditional theory, if the extranuclear electrons of atoms are an electron cloud with all electrons performing irregular motion, how could bonds corresponding to the number of valence electrons form, and how could such neat and orderly crystals arise?

We have discussed above covalent crystals with 4–7 valence electrons. Then how do metals with only 1, 2, or 3 valence electrons constitute their metallic crystal structures such as face-centered cubic and body-centered cubic? To address this, we must first understand the forces that construct objects, bind atoms of matter together, and provide cohesion namely, the valence-sharing force and the electromagnetic force.

Valence-sharing force: in essence it is the attraction of the proton field for electrons, a cohesive force. Above, we discussed structural units; we call the aggregating force by which valence electrons orbit two cores to form structural units the valence-sharing force. The valence-sharing force is the principal bonding force in nonmetallic crystals, not the so-called covalent bond or polar bond.

The valence-sharing force is related to the number and distribution of valence electrons and is proportional to the square of the orbital speed of valence electrons; the more valence-sharing electrons and the higher their speeds, the greater the valence-sharing force, and the more tightly atoms are bonded. The kinetic energy of valence-sharing electrons thus constitutes the binding energy between the two atoms within a structural unit.

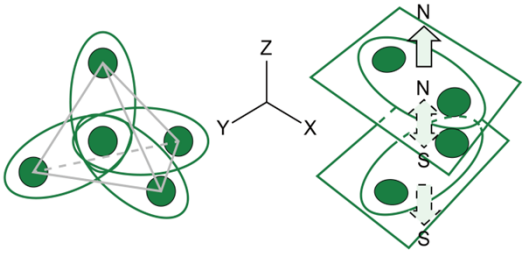


Figure 5-5. *Valence-sharing structure (left) and the electromagnetic-force structure of metals (right).*

5.5. The Constitution of Metallic Bodies

In metallic substances the atomic outer shell has only 1–3 valence electrons; valence-sharing motion can form only 1–2 scattered structural units and cannot form multiple structural units that combine into a spatial structure. Then how do Cu and Ag with only 1 valence electron, and Fe and Ni with 2 valence electrons, constitute their metallic crystal structures?

For this, Nature has long had a meticulous arrangement: earlier we discussed six major properties of electrons, among which are: 4) electron motion simultaneously generates a magnetic field and is accompanied by magnetic-field force, with the direction of the magnetic force perpendicular to the direction of motion… and Nature has even specially arranged the right-hand rule. Such finely endowed consummate magnetism is not for making lodestones but for the aggregation of like substances; to construct metallic structures and to create the connections between metallic structural units the electromagnetic-force structure; and it also gives rise to metals' ductility and to metallic phase transitions.

Let us first recall Oersted's classic experiment, which tells us that electron motion is accompanied by an electromagnetic field.

Electromagnetic force. When valence-sharing electrons orbit at high speed, a relatively strong magnetic force is generated in the direction perpendicular to the plane of rotation. Each metallic structural unit is like a tiny magnet; these units' north and south poles

attract each other. Magnetic force attracts structural units into relatively fixed positions, forming another cohesive force of matter the electromagnetic force.

Metals have few valence electrons; for example, copper has only one valence electron, so every two copper atoms can combine into only one structural unit. When its valence-sharing electron rotates at high speed, a relatively strong electromagnetic force with a north–south orientation is generated in the direction perpendicular to the central plane of the elliptical orbit. Innumerable structural units in multiple orientations rely on electromagnetic force to attract one another and align neatly, constituting the metallic structure of copper (Fig. 5-5, right). The rhombi indicate the planes in which valence-sharing electrons orbit; the two planes above and below are parallel, and the electromagnetic-force poles generated by valence-sharing electron motion attract each other north-to-south. At the same time, there is valence-sharing electron motion in planes perpendicular to this plane, forming electromagnetic forces in three-dimensional directions to constitute the metallic structure.

Because metallic structural units are maintained by electromagnetic force, they are like innumerable tiny magnets mutually attracted and bonded together. When subjected to relatively large external forces, structural units can slip and swap positions within the material and recombine. Thus, metals possess ductility and plasticity. Without electromagnetic force, physics could never explain the natural facts that gold can be beaten into leaf, silver can be drawn into fine wire, and steel plate can be stamped into a cup.

Because the structures among all metallic structural units are maintained by electromagnetic force, structural units of different metals can also be combined by electromagnetic force. Therefore, different metals are not constrained by definite chemical composition; they can combine in arbitrary proportions to form alloys. (This was also a question I asked my teacher years ago.)

Because metals have few valence electrons, valence-sharing electrons move at high speed and are accompanied by very high-frequency electromagnetic waves. Such high-frequency electromagnetic waves can reflect light of certain frequencies, hence many metals possess metallic luster. Modern physics has not told children where metallic luster comes from and why a smooth metallic surface can reflect light.

The theory of the metallic bond is not only forced in its bonding theory but entirely unable to interpret metallic ductility and plasticity, nor can it explain metallic luster, much less why metals melt (undergo phase transition) at high temperature. A commonplace phase transition thus becomes a scientific mystery. Once the source of the forces constituting objects is understood, there is a direction for interpreting material phase transitions.

The magnitudes of the valence-sharing force and the electromagnetic force depend on the speed of valence-sharing electrons and the stability of their trajectories. The valence-sharing force and electromagnetic force generated by the motion of valence-sharing electrons form the cohesive force of matter, constituting the shape of matter, constituting the strength of objects, leading to the various properties of matter, and giving rise to a colorful material world.

5.6. The Contributions of Structural Units

Structural units are, except for inert elements, the basic mode by which all atoms mutually bond the necessary process by which atoms mutually bond to constitute matter in keeping with Nature's consistent method of creation. The principles are systematic, the structures simple, and the applicability broad. Structural units can provide a unified description of the structural constitution of metals, nonmetals, and compounds and of the evolution of structure (chemical change), and they apply to the constitution of almost all materials and even to phase transitions.

The preconditions for forming structural units are very explicit and simple: the widely recognized attraction of the atomic nucleus for electrons the proton field attracts electrons, constituting the valence-sharing surrounding orbital motion of electrons. In this way, connections are formed between two, three, or five atoms, and ultimately among all things, revealing Nature's simplicity and sagacity in creation.

Structural units constitute crystals, constitute molecules, constitute gases, liquids, and solids, and form chemical reactions. They constitute organic matter, constitute the bases of DNA, enabling connection and replication; constitute proteins; constitute cells; and constitute living beings. Following the periodic table of the elements, they are the universally present, inevitable bonding form by which elemental structures constitute matter.

Nature's practice is the utmost simplicity: using one bonding mode structural units to realize the connections of all atoms is certainly simpler and more effective than seven or eight types of chemical bonds, and the key is logical coherence. With structural units alone one can interpret the plasticity and ductility of metals, the brittleness of nonmetals, and the multiple properties of all materials. Using the speed of valence-sharing electrons and orbital radii accounts for the ease or difficulty of material bonding, and changes in bonding force can be interpreted in terms of the motion and variation of valence electrons.

Structural units are an important mode of atomic bonding and the main reason atoms connect to constitute various substances. They

can interpret the structures of solids, the flow of liquids, the buoyancy of gases, material phase transitions, the mystery of catalysis, and the mystery of superconductivity; all such interpretations proceed smoothly on both fronts.

Nature cleverly transforms the basic attraction of the proton field for electrons into a bonding force of matter the valence-sharing force via structural units. This force is realized through the motion of valence-sharing electrons; it is one of the principal forces constituting molecules and matter and combining them into objects. When the motion of valence-sharing electrons changes, the bonding force of matter can also change, laying the groundwork for changes in the principal structural force of objects namely, material phase transitions. Of course, material phase transitions are closely related to the forces constituting the object and to temperature. It is therefore necessary here to first understand what temperature heat is.

6. Questions in Thermodynamics

Heat is temperature; it is the temperature field of the two particles and three fields. Thermology is one of the principal branches of physics.

Modern physics invariably calls thermology "thermodynamics." People long ago noticed that the cohesive force of matter the force that holds bodies together changes with temperature, and that temperature can induce phase transitions; even steel melts at high temperatures. By what warrant does temperature possess such wondrous power? How do heat and temperature exert a magical effect on the cohesive forces of matter? This is a mystery of modern science an issue physics must answer, yet still cannot. Temperature is closely connected with mechanics and with the structure of matter; temperature is the prime mover behind changes in structural forces in matter, even behind phase transitions.

6.1. Physical Thermology: Heat and Light

Physical thermology focuses on temperature, heat, work, and energy. Although it is evident that heat is related to material properties, it has been difficult to integrate temperature with the mechanical properties of materials in a unified investigation. Over the past 200 years, scientists have established several thermodynamic theorems based on the thermal phenomena of matter, yet they know very little about the underlying mechanisms.

It has been observed, however, that heat and light are intimately connected. Thermology and optics are two major branches of physics, each an independent discipline. Yet Nature constantly reminds us to study heat through light: strike a match and combustion is accompanied by both light and heat; the familiar candle flame is orange-yellow; a coal fire at 700 °C appears orange-red. Why is fire red? This is the first physical question one faces concerning light and heat.

Insert an iron wire into a furnace; one end is heated. Fresh from the furnace, the wire glows bright yellow; as the temperature gradually drops, its glow shifts from bright yellow to orange, to red, to dull red; finally, the visible glow vanishes, though residual heat remains, and the hot wire continues to radiate infrared. As the temperature falls, the frequency of the light gradually decreases. What is the underlying cause?

One hundred and ninety years ago, German researchers conducted experiments on the relation between temperature and the wavelength of thermal emission, establishing Wien's formula and confirming that at higher temperatures the wavelength of thermal radiation shortens (the frequency increases). Unfortunately, those early explorers did not pursue further: Where does firelight come from, and why does its color change with temperature?

$$\lambda T = 2.879 \times 10^{-3}\ \mathrm{m} \quad (1)$$

$$\lambda f = 3 \times 10^{8}\ \mathrm{m\ s^{-1}} \quad (2)$$

$$T = 9.96 \times 10^{-12}\ f \quad (3)$$

Wien's formula emphasizes wavelength; my focus is frequency, because this frequency is the orbital speed of the extranuclear electrons. Conclusion: The temperature T of matter is directly proportional to the frequency Hz of thermal emission: higher temperature higher emission frequency.

6.2. Temperature the speed of extranuclear-electron orbital motion

That the frequency of firelight changes with temperature is Nature's hint an important clue for probing the internal mechanisms of matter. The light emitted by combustion is in fact electromagnetic radiation, whose frequency spans from microwaves and infrared to the visible red, orange, yellow, green, cyan, blue, violet from low to high. Connecting and summarizing these physical items yields the following table:

Flame color	Light-wave frequency ($\times 10^{14}$ Hz)	Flame temperature ($\times 10^{2}$ °C)	Relative electron speed
Dim red	3.8	2.2	Low
Red	4.8	5.5	
Orange	5.0	7.6	

Yellow	5.2	8.8	
Blue-white	6.2	14	
White (cyan–violet)	7.5	22	High

Table I. *Flame color, light-wave frequency, temperature, and relative extranuclear-electron speed*

From the list (first row center, from right to left) we see that a hot iron wire glows bright yellow; as its temperature gradually decreases, its glow shifts from bright yellow to orange, to red, to dim, and finally goes out. The frequency of its light likewise decreases from high to low. The gradual change in color corresponds exactly to the change in electromagnetic frequency! The temperature of matter bears a precise proportional relationship to its emission frequency, thereby revealing the natural connection between heat and light, and between heat and the orbital speed of extranuclear electrons.

The facts of thermal emission show that the electrons' orbital speed tracks temperature. As temperature falls electron speed slows. Hence, we observe the progression from orange to red, and from red to dark; conversely, as temperature rises, the orbital speed of extranuclear electrons increases.

Firelight is emitted by transitions of valence electrons; high temperature high extranuclear-electron rotational speed high frequency of electron-transition emission. This is Nature, through firelight, instructing us that the orbital speed of the extranuclear electrons in matter changes precisely with temperature an evident and important physical reality.

Spectroscopic experiments 160 years ago likewise confirmed the regularity of extranuclear-electron motion. Spectroscopy tells us that emission from matter is closely related to the orbital speed of extranuclear electrons.

The principles of combustion emission and Bunsen spectral emission are the same: both arise from transitions associated with the orbital motion of extranuclear electrons. The fact that atoms of the same element exhibit the same color and the same spectral lines at the same temperature indicates that the paths and speeds of extranuclear-electron motion in matter are uniform and highly regular.

6.3. Temperature and ordered motion in matter

One hundred and ninety years ago, physicists set thermal emission aside and, based solely on macroscopic Brownian experiments, defined "heat as the random motion of a vast number of molecules." The experiments are factual, and the definition is not incorrect; however, temperature is broad in scope, and thermological research should not be confined to the narrow domain of "liquid-state molecular" behavior. That higher temperature accelerates Brownian motion is a phenomenon, not the essence; it cannot interpret the first-principles physical causes behind larger temperature-difference, phase-transition phenomena such as thermal emission, the melting of iron, or the boiling of water (phase change).

Precisely because the orbital speed of extranuclear electrons varies with temperature, all temperature-related phenomena in matter its constitution, its phase transitions, the Curie point of magnetic substances, shape-memory alloys, superconductivity, superfluidity, and other temperature-related physical phenomena are the results of extranuclear electrons undergoing faster or slower ordered motion.

Extranuclear electrons can not only absorb high-frequency electromagnetic waves from the environment, thereby increasing their own speed and temperature and inducing phase transitions, loss of magnetism, and other physical changes; when the temperature of a substance exceeds that of its surroundings, the orbital motion of that substance's extranuclear electrons will undergo transitions and radiate electromagnetic waves outward, thereby lowering its own temperature. Hence, we also have: heat always flows from a high-temperature environment to a low-temperature body (the second law of thermology).

Although different substances all emit heat and light when burning in air, their flame colors differ markedly: the aforementioned orange-yellow of matches and candles is the flame of burning hydrocarbons; carbon monoxide burns with a blue flame; magnesium burns white; copper burns green; sodium burns with its characteristic yellow sodium light. These differing colors show that the electron speeds of different substances vary, revealing information about the intrinsic frequencies of intra-atomic electrons.

As temperature changes, water freezes at 0 °C and boils at 100 °C; the physical phase of H_2O undergoes a dramatic change. A magnet loses its magnetism at the Curie point; a shape-memory alloy "remembers" at a specific temperature; superconductivity and superfluidity are qualitative changes in material properties occurring at extremely low temperatures. Modern physics has merely recorded the initial states and final outcomes of these changes, while the intermediate processes and mechanisms have become scientific mysteries.

That intermediate process is this: there exists a logical connection between the orbital motion of extranuclear electrons and the temperature of matter; therefore, changes in material properties during temperature variation should be attributed to changes in the orbital speed of extranuclear electrons. We thus have grounds to directly examine temperature and the ordered motion of electrons, and to find the causes of phase transitions within that motion.

Temperature is one of the three fields; it is the external condition governing the orbital speed of extranuclear electrons. The ordered motion of electrons is the most active and vigorous factor outside the atomic nucleus. The temperature-governed ordered motion of extranuclear electrons is the root source of material constitution and of its physical, chemical, and biological properties. Temperature is the external condition of material phase; it is the physical field that regulates the orbital speed of extranuclear electrons. The orbital speed of extranuclear electrons is the carrier of temperature and the builder of material phase.

6.4. Several inferences in thermal physics

Knowing that heat is the temperature of matter and determines the speed of its extranuclear electrons; that heat is a necessary and important physical field for the existence and transformation of matter; we can thereby locate the logical roots of temperature-related properties of matter: in the physical world, the emergence and change of all temperature-related physical properties are connected with the motion of extranuclear electrons. On this basis we can make a series of well-reasoned inferences.

Inference 1. Basis: temperature orbital speed of extranuclear electrons. All scientific inquiries related to temperature should first consider the corresponding speed of extranuclear-electron motion. Studies of melting points, boiling points, Curie points, and superconducting critical points must be correlated with the orbital speed and state of extranuclear electrons at those temperatures.
Inference 2. The structures of materials exist under specific temperature conditions; temperature changes structure changes phase transitions. The current state of a material's structure ice, water, or vapor is a thermal existence and is the outcome of the motion of its extranuclear electrons. Thus, the current structural state of a substance is the result of extranuclear-electron motion under that temperature condition.

Inference 3. The properties of materials are linked to temperature and thus to the paths and speeds of their extranuclear electrons at that temperature. Heat treatment of metals employs temperature variation and isothermal holding to alter mechanical properties. Therefore, heat treatment uses dopants and changes in temperature and time to control the orbital speed of extranuclear electrons in metals, thereby changing material properties.

Inference 4. Heat can do work and possesses energy. Thermal emission shows that thermal energy is directly related to light energy. Heat is one among many forms of energy in physics; since energy can be transformed from one form to another, thermal energy can be interconverted with other forms light, electrical, and chemical energies.

Inference 5. If heat is the orbital speed of extranuclear electrons, then heat transfer is the transfer of the orbital speed of extranuclear electrons that is, the alteration of the orbital speed of the relevant matter's extranuclear electrons. Heat transfer proceeds via convection, conduction, and radiation; hence heat transfer is the change in extranuclear-electron orbital speed effected through these three channels.

Inference 6. Chemical reactions are often accompanied by endothermy, exothermy, explosions, and other temperature phenomena; therefore, chemical reactions must be closely related to the paths and speeds of electron motion. The principle of catalysis is to change the speed of the reactants' extranuclear electrons so as to synchronize the speeds of the valence-sharing electrons, thereby facilitating the reaction.

Inference 7. Superconductivity occurs at extremely low temperatures; therefore, during superconductivity the orbital speed of extranuclear electrons is especially slow, and the formation of superconductivity is related to the extreme slowing of extranuclear-electron speed.

Laser cooling of atoms is precisely the control of extranuclear-electron orbital motion so as to bring the temperature down to absolute zero.

Inference 8. If temperature is the orbital speed of extranuclear electrons, and the frequency of thermal emission is the contemporaneous speed of extranuclear electrons, then one can use temperature and thermal emission to examine the orbital speed of a body's extranuclear electrons.
Inference 9. The existence of precise melting and boiling points for pure substances indicates that the rotational speeds of extranuclear electrons in a pure substance are precisely synchronized and are definitively and closely connected with temperature; phase transitions are synchronized changes in electron motion under specific temperature conditions.
Inference 10. The disappearance of magnetism at the Curie point shows that macroscopic magnetism is related to temperature and therefore must be related to the motion of extranuclear electrons at that temperature. Modern magnetism, constrained by quantum theory, avoids ordered motion of extranuclear electrons and is compelled to focus on electron spin instead.

"Temperature electron orbital speed" reminds us that studying the ordered motion of extranuclear electrons is the key to unlocking material properties and their changes. Thermal phenomena in matter are all results of the ordered motion of extranuclear electrons; any scientific inquiry related to temperature should first consider extranuclear-electron motion for example, in phase transitions.

7. Phase Transitions of Matter

A phase transition is a physical phenomenon in which a substance's bonding forces, morphology, and properties undergo drastic changes under specific temperature conditions; water freezes when cooled (< 0 °C), tin melts next to a soldering iron (> 230 °C) … Yet despite centuries of unremitting effort, humanity has still not unraveled these common and conspicuous natural phenomena.

Atoms in a solid are firmly connected, and the whole exhibits strong cohesive force. However, as temperature varies, hard ice becomes flowing water, and reinforced iron and steel become glowing molten steel and iron. How does the cohesive force that supports a solid framework disappear where does it go? How does a phase transition form? This has long been a scientific puzzle perplexing humankind.

Chemical bond theory classifies crystals into various categories and discusses various bonding forces very impressive indeed! But ask this: when tin melts into a liquid under a soldering iron, where do its metallic bonds go, and how do the bonding forces disintegrate? How does heating water produce steam? The usually well-articulated chemical bond theory falls collectively silent.

Modern physics bypasses chemical bonds and broadly attributes the internal cause of phase transitions in matter to molecular thermal motion. But how does heat loosen a solid's structure, and how do the solid's chemical bonds disintegrate? Why do phase transitions exhibit distinctive, fixed temperature points? This has remained a century-old conundrum for physics.

7.1. Temperature and Structural Forces

The physical properties a substance possesses strength, hardness, electrical conductivity, magnetism, and so forth refer to properties it has in a given phase. As temperature rises, general substances undergo a phase transition from solid to liquid and from liquid to gas, and their formerly robust properties vanish without a trace. How does temperature act? How does it change the phase of matter?

The temperature field is one of first-principles physics' two particles and three fields; it is an important physical foundation. From the previous chapter we learned that temperature is essentially the macroscopic manifestation of the orbital speed of extranuclear electrons. When temperature rises, the speed of extranuclear electrons increases. As temperature rises and reaches a certain level, water can boil and steel can melt.

Temperature can induce phase transitions; temperature can change the orbital speed of extranuclear electrons. The logical connection is this: changes in the speed of extranuclear electrons are the direct cause of phase transitions in matter! Thus, the logical focus is: how electrons with changed speeds move, and how they induce phase transitions precisely what this chapter will resolve.

Previously, we discussed internal forces in matter. Solids have definite shapes, definite rigidity, and can withstand certain external forces, which shows that the microscopic structure of a solid has stable internal forces structural forces.

The structure of a typical solid is composed of metallic and nonmetallic structural units in fixed positions: in nonmetals, multiple valence-sharing electrons in ordered orbital motion form valence-sharing crystals and ionic crystals; in metals, valence-sharing electrons in ordered orbital motion generate electromagnetic force, with north–south pole attraction, orderly and stable, forming the metallic body (while also conferring ductility).

Therefore, in solids the directions of valence-sharing forces and electromagnetic forces are highly stable, and the positions of structural units are relatively fixed, forming crystals and the rigid structure of solid bodies. A phase transition (melting) is the reduction and elimination of a body's cohesive force the destruction of the solid's stable internal structure.

Temperature is the key factor that induces a phase transition, namely: rising temperature → accelerated orbital motion of valence-sharing electrons → reduction of the substance's cohesive force (valence-sharing force and electromagnetic force) → collapse of the solid structure → phase transition. These basic relations are logically smooth. The key is to examine specifically how a change in temperature i.e., a change in the speed of extranuclear electrons brings about the occurrence of a phase transition in matter.

7.2. Phase Transition, Collapse of Cohesive Force Melting

Phase transitions are directly related to temperature, yet only when a specific value is reached can a phase transition occur; this is a process from quantitative change to qualitative change. That rising temperature accelerates extranuclear electrons is certain. But how can accelerated electrons increase a material's plasticity and lead to a phase transition? Physics faces the task of exploring the logical linkage: rising temperature → accelerated extranuclear electrons → reduced cohesive force.

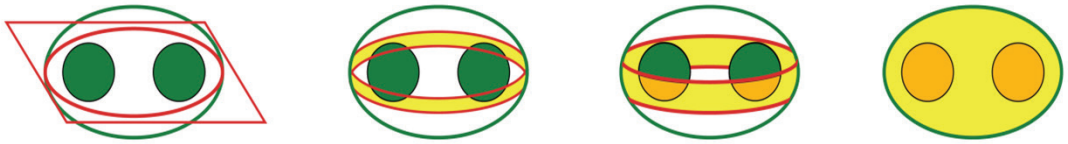
Speaking of phase transitions, the key is the change in cohesive force. We learned that a force has three elements: magnitude, direction, and point of application. Inside matter, the internal forces (structural forces) that constitute matter also possess these three elements, and these three elements play a critical role in the phase state of matter. Solid structures are supported by electromagnetic forces and valence-sharing forces. If valence-sharing electrons were forever to move in a plane, then by the right-hand rule the direction of the

electromagnetic force would be stable, and the object would remain perpetually stable.

Observing the state of an object as temperature rises: it undergoes three processes thermal expansion, increased plasticity, and melting indicating that during heating the cohesive force of metals undergoes massive attenuation. Here we will stepwise examine the changes in the electromagnetic force of metallic structural units during heating, to see how raising temperature causes a metal to collapse and melt.

Thermal expansion and contraction (slight increase in the radius of structural units)
As temperature rises, the speed of valence-sharing electrons increases and their orbital radius grows, causing slight thermal expansion of the object. In fact, when temperature changes, matter generally exhibits thermal expansion and contraction within a very small range (copper: 17×10^{-6}/°C).

Increased plasticity (valence-sharing electrons begin twisted orbital motion)
As temperature continues to rise and the speed of valence-sharing electrons increases, they more readily enter the region of magnetic hysteresis (namely, after electrons orbit, the magnetism associated with their motion temporarily lingers), forcing electrons that were moving in a plane to deviate from their prior elliptical planar orbits and twist upward and downward. When heated to a certain temperature, the valence-sharing electrons with increased speed, under the influence of the lingering magnetic field, leave their original plane, as in Fig. 7-1 (1)– (2) (the quadrilateral denotes the plane of valence-sharing motion), and perform twisted motion within small intervals above and below the elliptical plane (gray regions). In this twisted state, electron paths are longer and their speeds higher.



(1) solid *(2)increased plasticity* *(3)liquid* *(4)gas*

Figure 7-1. *Orbital paths of valence-sharing electrons and the phase state of matter: (1) solid, (2) increased plasticity, (3) liquid, and (4) gas.*

When the orbital paths of valence-sharing electrons undergo small up-and-down twists, the electromagnetic force perpendicular to the valence-sharing motion also undergoes wobbling and swaying (by the right-hand rule), causing the directions of electromagnetic forces between structural units to sway and misalign. Under external force, structural units can more readily move and exchange positions. Macroscopically, the cohesive force decreases and the object's plasticity increases this is the moment to "strike while the iron is hot."

Melting (large-range twisting of valence-sharing motion)
Melting is the phase transition from solid to liquid and also the process of a solid losing its internal force. As temperature continues to rise and the speed of valence-sharing electrons increases further, magnetic hysteresis enlarges the up-and-down twisting interval of electron orbits, as in the wider central band of Fig. 7-1 (2). The electromagnetic force perpendicular to the valence-sharing motion experiences greater twisting and swaying, causing the directions of electromagnetic forces between structural units to wobble and misalign. Under external force, structural units more readily move and exchange positions. Macroscopically, the cohesive force diminishes and the object softens with increased plasticity; the solid structure, having lost internal support, collapses, leading to liquefaction of the substance a phase transition occurs.

As temperature continues to rise and reaches the melting point, the speed of valence-sharing electrons is even higher and the up-and-down twisting region of their motion becomes larger, as in the relatively wide central region of Fig. 7-1 (3). The direction of the associated electromagnetic force then swings widely and loses points of application; structural units lose the support of directional electromagnetic forces and are simultaneously disturbed by lateral electron-repulsion forces. Structural units within the substance change places, roll, turn, and reorganize. The internal forces that formerly supported the metal's structure and stabilized the object are completely dismantled the object has melted and transitioned to a liquid.

Vaporization (spherical enclosure of valence-sharing motion)
With a sharp rise in temperature, valence-sharing electrons move even faster. Magnetic hysteresis further distorts their motion, and their paths form an all-encompassing ellipsoidal spherical surface, as in Fig. 7-1 (4). Electrons on the surface of the ellipsoidal sphere repel one another; this repulsion pushes molecular spheres apart, forming a gas. In the figure, the shaded region indicates the ellipsoidal spherical region in space where valence-sharing electrons undergo twisted motion.

The process of phase transition is reversible: as temperature decreases, a gas can liquefy, just as water vapor in air condenses and becomes rain; this will be discussed in the next section.

The above interprets the entire process of solid–liquid–gas phase transitions in metallic substances using changes in the orbital speed of extranuclear electrons in valence-sharing motion and in their paths, along with the magnetism Nature endows to electron motion; the reverse process likewise holds naturally (omitted). Thus, the long-perplexing riddle of phase transitions is readily resolved. We see therein the wisdom of Nature's arrangement and the rigor of its logic. That a not-so-complicated phase transition became an unsolved mystery was due to the early straitjacket of the electron cloud theory; once thought breaks out of its cage to focus on the ordered motion of electrons, scientific riddles can likewise be proclaimed to the world.

It should be noted that within a liquid, matter still exists in the form of structural units. These structural units form chains, clusters, and rings merging and separating over time and cannot form a neat and continuous framework, yet there remain certain valence-sharing forces and electromagnetic forces internally (with disordered directions and momentary variability). Precisely thus do they constitute the cohesive force of the liquid, the Brownian motion of molecules within the liquid, and the surface tension of the liquid. As temperature decreases, electromagnetic forces between structural units in the liquid become relatively more stable and the cohesive forces between structural units increase; macroscopically, viscosity increases and surface tension increases.

7.3. Phase Transitions of Nonmetals

Nonmetallic substances, such as covalent crystals like silicon and compound crystals like table salt, do not have cohesive forces that are electromagnetic forces and thus do not undergo phase transitions arising from electromagnetic-force disorder. Therefore, melting of nonmetallic structures requires higher temperatures.

Taking a silicon crystal as an example to explore its phase transition process: each silicon atom's four valence electrons respectively form four structural units with four neighboring atoms, such that all atoms are connected by structural units into a continuously repeating silicon crystal. The valence-sharing force formed by structural units is the principal cohesive force of the crystal.

Each silicon atomic core is surrounded by four structural units, and the valence-sharing electrons of these four structural units must, in due order and with strict regularity, pass around the central atom. From this it follows that all valence-sharing electrons in a silicon crystal have uniform speeds. That is, in a covalent crystal one cannot change the speed of just a single valence-sharing electron; one must change the speeds of all crystal atoms' valence electrons in lockstep i.e., heat slowly. If not synchronized, some structural units' valence-sharing electrons will fail to be in place, the structure will break, local structural disorder will arise in the crystal and rapidly expand; macroscopically, the crystal cracks and is damaged. This is why covalent and compound crystals are highly brittle and prone to cracking.

The thesis of ordered orbital motion of extranuclear electrons not only interprets phase transitions but also explains the brittleness of nonmetals and the difficulty of their phase transitions, in complete accord with natural facts.

Latent heat of phase transition During a phase transition, when heat is supplied from outside, the object does not rise in temperature and no macroscopic phase change occurs; rather, the number or proportion of valence-sharing electrons tending toward nonplanar orbital motion increases, heightening the tendency toward a phase transition (melting). This is the latent heat of phase transition. This latent heat does not raise the temperature of the substance, i.e., it does not accelerate the speed of valence-sharing electrons. Instead, as this latent heat is transferred, it gradually equips electrons in planar motion with the kinetic energy reserved to "leap" from planar to nonplanar motion. Valence-sharing electrons in planar motion marshal their strength and, at the critical juncture, collectively break free of the constraints of electromagnetic forces to undergo nonplanar orbital motion, bringing about the melting of the substance.

8. Rain, Thunder, and Lightning

Phase transitions include not only melting but also vaporization and condensation: at relatively high temperatures, water becomes vapor molecules that, under the full enclosure of valence electrons, rise into the sky and are uniformly distributed among the abundant atmospheric nitrogen and oxygen; when they encounter cold air, the water vapor condenses into clouds and gathers into rain that falls. Yet a question remains: how do these discretely distributed water-vapor molecules in the air recognize their own kind, find their own kind, aggregate and condense into clouds, and coalesce into rain?

8.1. Water Molecules

Water is the most ordinary and common liquid substance, the source of life. People take the freezing point of water as the zero point for recording temperature and set the boiling point of water at 100 °C, using water's phase-transition points as the yardstick of natural temperature.

It is known that water has a definite chemical composition of one oxygen and two hydrogen atoms. Why must it be combined in this way? The sum of valence electrons in H_2O (1+1+6=8) matches the natural periodicity of 8; on a spherical surface, uniform distribution corresponds to 8. Therefore, stable combinations in compounds all render the sum of valence electrons equal to Nature's favored 8, or an integer multiple of 8, for example, carbon dioxide CO_2 (4+6+6=16), salt, calcium oxide, and so on.

The combination of oxygen and hydrogen is full of vigor: originally, in hydrogen and oxygen gases, each has very high valence-electron speed and high energy; upon combination they burn intensely and release a large amount of energy. After hydrogen and oxygen combine, they attain a low-energy stable state and become water; the valence-sharing electrons have reached their minimum speed and can no longer release energy outward. To separate the hydrogen and oxygen structural units, one must increase the speed of the valence electrons and input a great deal of energy. Claims that adding a small amount of some substance to water can light a lamp or run a tractor are evidently deceitful talk.

Water appears in the forms of clouds, rain, brooks, rivers, lakes, and seas, circulating and traveling in nature. Yet to this day, the water we drink and use every day has left so many riddles:

Why is the density of water maximal at 4 °C, and why does its volume expand as it gets colder below 4 °C?
Why does the boiling point of water decrease under low air pressure, making it difficult to cook rice properly on the plateau?

How does water vapor in the sky find companions and come together as rain?

One oxygen and two hydrogen atomic nuclei each attract one of the other's valence electrons and combine into two interlinked structural units, forming a water molecule (Fig. 8-1).

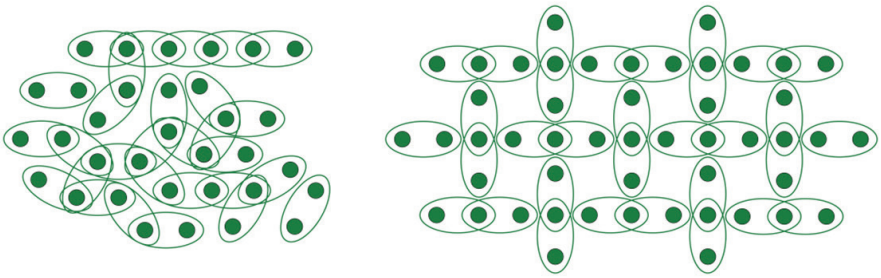


Water molecule *water vapor*

Figure 8-1. Water molecule and water vapor. The oxygen atomic core is central and the hydrogen nuclei are on either side; gray denotes the orbital region of valence-sharing electrons.

The left side of Fig. 8-1 shows the basic constitution of water. Between 0 °C and 100 °C, the rotational paths of the valence electrons in these structural unit twist within the gray region, causing the direction of the associated electromagnetic force to be unstable and preventing the formation of a stable solid; thus, water molecules cluster together into chains and groups, intermittently combining and separating (Fig. 8-2A). The unstable electromagnetic force gives rise to the cohesive force of water. On the surface of water, more than a dozen layers of structural units connect and spread along the surface, forming the surface tension of water.

As the temperature continues to drop, the structural units gradually align neatly as in Fig. 8-2B; freezing occurs, the volume increases, and the specific gravity decreases.



A structure of water *B structure of the middle layer of ice.*

Figure 8-2. *Structures of water and ice: (A) structure of water; (B) structure of the middle layer of ice.*

Evaporation of water Under ambient temperatures and in well-ventilated air, water can naturally evaporate; at high temperatures it boils undergoing comprehensive evaporation to form water vapor. Evaporation occurs because, at higher temperature, the rotational paths of the valence electrons expand from a drum-shaped region to the entire spherical surface, and the structural units become fully enclosed by valence electrons (Fig. 8-1B); electrons on the molecular surface repel one another and push apart, and the water vapor ascends into the air.

8.2. Formation of Rain

In middle school, the teacher told us that water vapor rises into the sky, encounters cold air, condenses into clouds, and then gathers into rain. Yet a question also remains: the air contains a large amount of nitrogen and oxygen, while water vapor is less than one percent; the repulsion of the outer electrons causes water-vapor molecules to be uniformly distributed in the atmosphere. How then

can these water-vapor molecules "amid the vast sea of atmospheric molecules" recognize their own kind, join hands with their own kind, come together to condense into clouds, and coalesce into rain?

At different temperatures, the orbital speeds of different molecules in the atmosphere are not the same. At low temperatures, the valence electrons of water vapor in the sky are the first to slow down; their orbital paths change from oblate spheroidal to nonplanar, generating an opening and forming a drum shape (Fig. 8-3B). The wobbling electromagnetic force at the opening becomes manifest; the north and south poles of the electromagnetic forces of all the small drums attract each other, find companions, and come together into clouds. With a further drop in temperature, the mist and cloud aggregate into small water droplets, which fall and form rain.

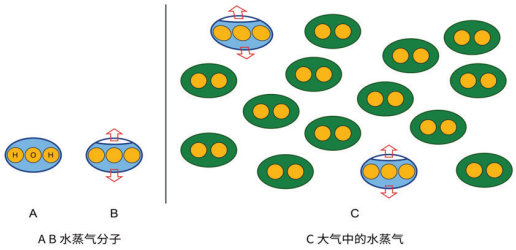


Figure 8-3. Water-vapor condensation: (A) a water-vapor molecule with a spherical electron path; (B) reduced valence-sharing-electron speed produces openings in the shell and exposes electromagnetic force; (C) electromagnetic force brings H_2O molecules together among atmospheric molecules.

Without considering the forms of valence-electron motion under different temperature conditions and the electromagnetic forces associated with electron motion, it is impossible to interpret the evaporation of water or how water vapor gathers into clouds in the sky, and one cannot answer how rain forms.

Having realized that water vapor can absorb free charges in the air, the development of thunder and lightning comes into focus: free electrons near the ground are absorbed and surround the water vapor; as hot air rises, the water vapor carries these surrounding additional charges aloft as well.

At high altitude, encountering low temperatures, the speed of the valence-sharing electrons of water vapor decreases; their paths shift from spatial spherical-surface motion to planar twisted motion; the water vapor condenses, undergoing a phase transition from gas to liquid, and aggregates into clouds. At this point, the extra component earlier added to the water vapor surplus electrons no longer has a place to reside. The surplus electrons are squeezed out, forming charges free within the cloud layer; these excess charges constantly attempt to squeeze back into H_2O to seize positions, disrupting charge balance and forming a voltage within the cloud.

A cloud layer is an aggregate of a large amount of water vapor undergoing phase transition into water, and therefore a large number of expelled charges also accumulate nearby. As the charges accumulate more and more, very high voltages can form. Enormous potential differences arise between cloud layers and between cloud layers and the ground; once a path is forced open, high-voltage charges traverse the atmosphere, causing electrons in surrounding matter to oscillate, producing the spectacular phenomenon of lightning; at the same time, the air is made to vibrate violently, producing the rumbling sound of thunder.

From the above, it is not difficult to see that thunder and lightning are by-products of water vapor transitioning into rain; lightning and thunder tell us that a large amount of water vapor in the air has already condensed into water, indicating that rain is likely to fall. (Dry thunder also occurs from time to time, because rainfall depends on many factors such as temperature, humidity, air pressure, and airflow.)

In winter, when the air temperature is low and the speed of the valence-sharing electrons is relatively low, most of the water vapor in the air condenses into water or ice. Thus, cold air is relatively dry, contains little water vapor, and carries few charges; therefore, thunderstorms are rarer in winter.

8.3. Latent Heat of Phase Transition

Crystalline substances have very precise melting temperatures the melting point. For a crystal to melt, the temperature must reach the melting point; only after continued heat absorption can melting occur. This fact indicates that the speed of extranuclear electrons in crystalline substances is perfectly definite, and the change in their motion is orderly and synchronous.

When a crystalline substance is heated to its melting point, melting cannot occur immediately; it is necessary to continue heating. During this continued heating, the temperature of the substance does not increase, indicating that at this temperature the substance absorbs heat without rising in temperature. Where then does this heat go?

This phenomenon has long attracted the attention of researchers. People call this "disappearance" of heat during a substance's phase transition latent heat. Where does this heat hide? This is a matter of interest to many students and scholars. Below, we will discuss the latent heat of phase transition using the melting of ice as an example.

Below 0 °C, the structural units of ice undergo planar motion, and ice blocks are hard and stable. As external heating proceeds, the valence-sharing electrons in planar motion within the ice accelerate, and the temperature of the ice rises. At the melting point of 0 °C, the speed of the valence-sharing electrons in planar motion reaches its limit. With continued external heating, those valence-sharing electrons that have reached the limiting speed tend toward nonplanar orbital motion; however, due to the inertia of the overall planar motion of valence-sharing electrons in ice, and due to the mutual constraints of the material's internal directional valence-sharing forces and the interlinked motion of valence-sharing electrons, the few valence-sharing electrons that are heated first cannot achieve nonplanar orbital motion, and the phase transition cannot occur.

At this time, external heating does not raise the temperature and does not produce a macroscopic phase transition; it only increases the number or proportion of valence-sharing electrons that tend toward nonplanar orbital motion, thereby increasing the tendency toward the phase transition (melting). This is the latent heat of the phase transition. This latent heat does not raise the temperature of the substance or accelerate the speed of the valence-sharing electrons; rather, it gradually supplies planar-moving valence-sharing electrons with the kinetic energy to "take off" from planar to nonplanar motion, arming the planar-moving valence-sharing electrons with enough impetus so that, at the moment, they break free together from the constraints of electromagnetic forces, undergo nonplanar orbital motion, and produce the melting of the substance.

The melting process of metals is the same, and the latent heat of melting follows the same principle. Latent heat is used mainly to overcome the inertia of the overall motion of valence-sharing electrons, break free from the constraints of electromagnetic forces, and supply the kinetic energy for the transition from planar to nonplanar motion.
During melting, the initial local disorder in the direction of the electromagnetic forces of the structural units that are heated first excites and perturbs neighboring structural units, which must also accelerate the speed of their valence-sharing electrons to adapt to this change. Accelerating electron speed must absorb heat (absorbing electromagnetic radiation from the surrounding matter, thereby cooling the surroundings). The macroscopic manifestation is the endothermic phenomenon during melting; the drop in air temperature during snowmelt is caused by this heat absorption.

Evaporation of water Under ambient temperatures and in well-ventilated air, water can naturally evaporate; at high temperatures it boils undergoing comprehensive evaporation to form water vapor. Evaporation occurs because, at higher temperature, the rotational paths of the valence electrons expand from a drum-shaped region to the entire spherical surface, and the structural units become fully enclosed by valence electrons; electrons on the molecular surface repel one another and push apart, and the water vapor ascends into the air.

9. What Is Energy?

Energy, ubiquitous yet mysterious, long ago leapt beyond the scope of physics; it is one of the most commonly used words in contemporary society.

Energy is invisible and intangible, yet omnipresent.
Energy is nevertheless an important concept in modern science, widely used and saturating all current physical theories; however, our physics cannot decipher what energy is. Having discussed heat and phase transitions, we can now proceed to further explore energy.

9.1. Why can't carbon dioxide burn into carbon trioxide?

In middle-school chemistry we learned: some substances possess energy, can burn, and can give off heat and light. Combustion is a form of oxidation; carbon and oxygen, when incompletely burned, can form carbon monoxide, and carbon monoxide can continue to burn to form carbon dioxide.

At the time I wondered: carbon dioxide is also composed of carbon and oxygen; since both carbon and oxygen can burn, why can't carbon dioxide continue to burn into carbon trioxide or carbon tetroxide, and instead can even serve as a fire-extinguishing agent?

Some substances can burn and release heat where does this heat come from?
After a decade of perplexity, I became an engineer and checked the literature. The authoritative claim is: after combustion, entropy increases while enthalpy decreases. Then where is enthalpy? What is enthalpy? Why do carbon and oxygen have enthalpy, but after burning to carbon dioxide the enthalpy is gone? Entropy and enthalpy sound esoteric, yet they come and go without a trace no detail, no logic, merely two newly coined terms, a bluffing veneer.

It seems that the modern physical theory of combustion still has not touched scientific essence; it goes in circles and is hard to find convincing. In Nature, protons and electrons combine to form atoms; valence-sharing motion forms structure and yields function.

Seeking truth is not coinage of new terms; it must attend to motion, discover regularities and functions.

In my essay "VI. Problems in Thermodynamics" I noted: Wien's formula tells us that the frequency of thermal emission of a substance is in exact proportion to its temperature: higher temperature higher rotational speed of extranuclear electrons; the speed of extranuclear electrons varies regularly with temperature. Combustion is generally accompanied by (emits) high temperature, so combustion should be understood from the ordered motion of high-speed extranuclear electrons responsible for heating and light emission.

Look at the periodic table: the number of atomic valence electrons cycles from 1 to 8; extranuclear electrons are uniformly distributed as 2, 8, 18; the inert gases with 8 valence electrons have extremely stable chemical properties. In chemical experiments the materials of different elements that more readily undergo reaction generally do so such that the total number of shared outer electrons of the products reaches 8 or an integer multiple of 8, forming new molecules in a stable state, such as CO2 and H2O. Why does hydrogen burn with oxygen to form water only as a combination of two hydrogens and one oxygen? Because only two hydrogens 1+1+6 can equal 8; eight shared valence electrons uniformly distributed on the molecular surface in stable orbital motion can satisfy the molecular core's demand for electrons, thereby conferring stability and removing any need for the electrons to have very high speeds. Therefore, oxidation reactions that form stable states are always exothermic; extranuclear electrons always reduce their speed and radiate energy.

From the viewpoint of electron motion, combustion oxidation reactions occur because the extranuclear electrons of oxygen have very high speeds and are quite reactive; when oxygen combines with fuel atoms whose extranuclear electrons have relatively high speeds i.e., reacts the products reach a stable state, the shared valence electrons reduce speed, undergo transitions, and radiate electromagnetic waves, which macroscopically manifests as heat and light.

Carbon and oxygen combine to form carbon monoxide under conditions of insufficient oxygen. At that time their total number of outermost-shell electrons is 10; the valence electrons cannot be uniformly distributed and remain in a relatively high-speed, unstable state. If oxygen is sufficient and the temperature appropriate, they can further react to form carbon dioxide. Its outermost-shell electrons sum to 16 (two 8s), achieving the most stable state; the extranuclear electrons reduce speed, and most of the energy is radiated outward in the form of electromagnetic waves; the electron speed is maintained at a minimum and most stable level and can no longer be markedly reduced. This is a constraint of molecular composition; hence stable carbon dioxide will not burn further, and carbon trioxide or carbon tetroxide will not appear.

The light and heat emitted during combustion are in fact the burning substance lowering electron speed and releasing part of its kinetic energy. The chemical energy contained in coal, oil, and the like, at the microscopic level, is the kinetic energy of electrons at relatively high speed. During oxidation, when the total of extranuclear electrons reaches 8 (or 16), they reduce speed and form gases, emitting thermal energy that drives pistons and becomes mechanical energy. In this sense, our cars, ships, and airplanes are all in fact propelled by tiny extranuclear electrons; rockets and satellites are also sent skyward by tiny extranuclear electrons.

Over eons, solar radiation has accelerated the extranuclear electrons of the earth's lands and air; through photosynthesis it formed hydrocarbons with relatively high extranuclear-electron speed—plants (and oxygen), and animals; after eons, the earth's coal and oil were formed. Today we extract these hydrocarbons, use part of their extranuclear-electron speed, oxidize them, and drive automobiles and rockets. Nature's law is thus so harmonious and simple.

A currently popular topic is "turning water into oil." Some say this is a new scientific discovery and should be supported; others say it is scientific fraud. Can water be turned into oil? You can now judge.

As we just discussed, water's total count of extranuclear valence electrons is 8; it is already the lowest-energy stable state. To turn water into fuel, one must break water's lowest-energy state and substantially increase its extranuclear-electron speed; this requires inputting energy (electrolysis, adding chemical substances with extremely high electron speed). Doing so is not worth the candle; the resulting "water" is no longer water, nor is it any miraculous conversion of water into oil.

Recently, yet other "scientific workers" have reported astonishing results, claiming to be able to make gasoline from carbon dioxide! They can solve the world's energy problem and also reduce greenhouse gases… We now understand what energy is, and we know that the valence electrons of CO2 sum to two 8s; it is already the lowest-energy stable state, with electron speed at the minimum at room temperature. To turn it into energy-rich gasoline, first one must input a large amount of energy to raise the electron speed of carbon dioxide, breaking its lowest-energy stable state; second, one must change the structure to form high-octane hydrocarbons; this process likewise requires a large energy input.

Therefore, in theory (and in practice), it is possible to make gasoline from carbon dioxide, but the energy used in the process must exceed the energy the produced gasoline can yield (if surplus energy such as solar energy is used, that is a different concept); Nature's conservation of energy is not easily altered.

9.2. Why do humans breathe?

We humans and animals are breathing at every moment.
Why do humans breathe? The textbook answer is because the human body needs oxygen.

However, the human body inhales oxygen and exhales oxygen; setting aside the unchanging components of inspired air, the changing part is: we inhale oxygen (O2) and exhale oxygen (carbon dioxide CO2).

In terms of volume, the volumes of inspired and expired gases are equal. In terms of atom counts: we inhale two oxygens and exhale two oxygens, with one carbon thrown in what then is the significance of breathing?

Indeed, in terms of atom numbers and atomic mass, animal respiration seems to be a losing proposition. If one adheres to the electron-cloud theory and refuses to examine the speed of extranuclear electrons or the energy carried by electron orbital motion, this account will never be reconciled; scholars will never provide a logically consistent, convincing answer.

Has Nature installed in our bodies such large lungs and a complete respiratory system, with arteries and veins spread throughout to deliver and retrieve oxygen, merely to conduct this losing business? We are certain that Nature's work is precise and exquisite and highly efficient.

Breathing appears on the surface to be a biological phenomenon, yet the driver behind it—the prime mover is physics, is energy, is the speed of extranuclear electrons. An energy-based analysis shows that breathing has important and positive significance: we inhale oxygen molecules whose extranuclear electrons have very high speeds, and we also take carbon from within the body to react with oxygen in an oxidation reaction to form carbon dioxide whose extranuclear-electron speed is the slowest, which we exhale.

Thus, what we inhale oxygen is a molecule with fast electrons, and what we exhale carbon dioxide is a molecule with slow electrons. The extranuclear-electron speed of the oxygen we inhale is much higher than that of carbon dioxide (modern technology should be able to measure the speed of gaseous valence electrons). What humans and animals obtain from breathing is precisely this difference between high and low extranuclear-electron speeds energy.

Arterial blood, rich in oxygen with relatively high extranuclear-electron speed, circulates and delivers it to all parts of the body, enabling the atoms of these tissues and cells to acquire energy increasing their electron speed thereby invigorating the cells. The oxygen content of blood is an important indicator of an animal's vitality. Humans and animals breathe at every moment, and the energy obtained from breathing is much greater than that obtained from food. Of course, we must consume food, one important reason being to obtain carbon from it. Modern medicine always computes energy (calories) from the amount of organic carbon intake, because oxygen in the air is free and proportional to carbon.

Of course, having this carbon only indicates the potential to oxidize and form a certain amount of energy; if you do not exercise enough to expend that many calories, this organic carbon will accumulate in your body, forming fat and making you gain weight. Therefore, if you do not want to gain weight, control your caloric intake. Exploring the cycling of carbon in the human body and the acquisition of energy will be a meaningful medical topic.

Physical medicine can compute energy from oxygen intake. An average person breathes about 8 liters of air per minute (varying by individual; take a midrange value). By comparison, I estimate: when the oxygen in one liter of air is oxidized to carbon dioxide it yields about 2000 J of energy; the power of a living person is $2000\times8/60 \approx 267$ W, equivalent to continuously running a 250-watt e-bike or keeping a 250-watt lamp lit at all times; that is, people obtain about 250 watts of energy in ordinary breathing.

When you sprint or exercise vigorously, you certainly gasp for breath, reaching 40 breaths per minute, massively absorbing the energy of oxygen; only then can you output 2000–3000 watts of power.

On the surface, a cheetah chasing an antelope is a contest of speed; in essence it is a contest of oxygen supply and lung capacity to see who acquires more high-speed extranuclear electrons; these high-speed extranuclear electrons supply the energy for animal motion. Modern food labeling commonly uses calories to denote energy, e.g., how many calories are contained in this bread. Where do these calories come from? When you eat the bread, you merely ingest some hydrocarbons you do not ingest energy; the energy is released when the carbon of these hydrocarbons combines with oxygen:

1 kilocalorie = 4186 joules of energy

Of course, we also constantly consume energy; a typical figure is 87 kilocalories for one hour of walking.

From the above analysis we appreciate Nature's wisdom and finesse: humans inhale oxygen (O2) and exhale oxygen (CO2) of the same elements, yet the extranuclear-electron speeds of the two molecules differ greatly. Nature did not produce a "Google"-scale

multitude of extranuclear electrons merely to have them spin meaninglessly; She surely endowed these spinning sprites with ample functions speed and energy among them.

A fashionable modern term is "low carbon." This is because in the process of industrialization and modern living, humanity has consumed excessive oxygen and produced more carbon dioxide. Low carbon means conserving energy and emitting less carbon dioxide. In the clement Earth that Nature endowed with favorable winds and rains, green plants, through photosynthesis, harness solar energy, absorb the carbon in carbon dioxide, and produce oxygen. Planting more trees and reducing deforestation are also low-carbon, environmentally friendly actions, enabling people and animals worldwide to breathe high-quality air.

9.3. Exploring energy

In the previous discussion, we noted that carbon dioxide is already a stable, lowest-energy state and therefore cannot continue to burn; we also noted that although animal respiration appears to be a biological phenomenon on the surface, the driver behind it is the acquisition of energy in breathing.

Energy is one of the most commonly used words in society today. Energy is invisible and intangible, yet omnipresent. The physics titan Feynman said: "It is important to realize that in physics today, we have no knowledge of what energy is." Fifty years have passed, and Mr. Feynman's question still resounds. Energy, this omnipresent physical concept, has left modern physical theory in the awkward position of "not knowing what it is talking about," and yet it continues to be widely propagated.

In middle school we learned the various forms of energy kinetic and potential energy, electrical energy, chemical energy, solar energy; we learned about energy conversion and conservation of energy. What is energy, how does it convert, and why is it conserved? These have long perplexed the scientific community as a natural enigma.

Here, to explore energy, we first start with visible forms of energy kinetic energy and potential energy.

A speeding train possesses kinetic energy; water upstream of a waterfall carries potential energy; a roller coaster in an amusement park is an excellent embodiment of conversion between potential and kinetic energy. From this we find: kinetic energy is the energy contained in the motion of matter (mass), while potential energy is poised to act about to move and we can specify the direction in which the potential-energy-bearing material is about to move. The two interconvert in motion; macroscopic energy tells us that energy is closely related to motion and the tendency to move.

At the microscopic level, energy remains closely related to motion, most evidently electrical energy. Electrical energy arises from current the (macroscopic) motion of electrons in a conductor. Voltage electromotive force establishes the direction in which electrons are about to move; under the action of voltage, electron motion forms current and thus electrical energy. Clearly, electron motion carries electrical energy; electron motion is the carrier of electrical energy. Electrical energy can interconvert with thermal, chemical, optical, and other forms of energy; therefore, these various microscopic energies should also be related to electron motion.

We know that the most active and conspicuous motion within matter is that of extranuclear electrons; then "could the motion of electrons within matter be the carrier of these various microscopic energies?" This is a logically clear line of thought; our exploration should of course proceed along it. However, this reasonable line encountered an insurmountable barrier.

A century ago, the electron cloud and the uncertainty principle entrenched an agnosticism about electron motion, even arguing: the motion of particles is uncertain; probing the motion of a single particle is meaningless; studying electron trajectories and speeds betrays ignorance of quantum mechanics mere low-level, childish, antiquated classical thinking. Thus, a forbidden zone for research was demarcated by fiat, and a prison for thought erected. As a result, no one dared (nor was able) to logically connect precisely conserved energy with this "smoky, foggy" electron motion; the academic world avoided discussing the ordered motion of extranuclear electrons, depriving the exploration of energy of its direction.

Thermodynamics dared not explore the relationship between "heat" and the speed of extranuclear electrons; even when seeing firelight daily, it dared not entertain the physical association of heat and light with electron motion. It could only define heat at the molecular level based on macroscopic Brownian motion.

In earlier essays I noted that, in firelight, we find: the speed of extranuclear electron motion varies regularly with temperature; when matter absorbs heat and its temperature rises, extranuclear-electron speed increases. This is an important detail neglected by contemporary physics.

We reason: temperature the speed of electron motion; thermal energy the kinetic energy of extranuclear electrons. This answers what heat is, establishing a link between heat and extranuclear-electron motion; on a factual basis it forges a logical connection between thermal energy and the motion of extranuclear electrons.

When the temperature of a substance exceeds the ambient temperature, the substance radiates electromagnetic waves (light and infrared) outward and lowers its own temperature; low-temperature substances receive radiation, accelerate the speed of their extranuclear electrons, and raise their temperature. Natural substances, without contact, exchange heat with the environment via electromagnetic waves. In passing, this also reasons out the second law of thermodynamics.

Physical chemistry investigates chemical energy but shies away from the ordered motion of electrons in matter; in desperation it coined new terms, "enthalpy" and "entropy," which look profound yet cannot be internally justified. This renders chemical energy mysterious: why does oxygen have enthalpy, carbon have enthalpy, yet when burned to carbon dioxide the entropy soars and the enthalpy disappears where in matter is enthalpy hidden, and how did it escape? Severed from the actual internal linkage between ordered electron motion and energy, the fabrication of abstract neologisms has plunged physics into confusion. Avoiding ordered electron motion and extranuclear-electron speed cannot answer why humans breathe, nor the child's natural question: why do we pant after running.

Coining new terms and shackling thought can only cause modern physics research to lose its way; a variety of bizarre theories have yielded decades of scientific stagnation.

Over eons, solar radiation (light energy) accelerated extranuclear electrons on Earth; through photosynthesis this formed hydrocarbons with relatively high extranuclear-electron speed plants and animals (bioenergy) and oxygen. Eons later, coal and oil were formed; the extranuclear-electron speeds of these substances remained high (rich in chemical energy). Today we extract these hydrocarbons and, using part of their extranuclear-electron speed, oxidize and burn them to power cars and rockets. From chemical energy to thermal energy to mechanical energy to kinetic energy, Nature's law is thus harmonious and simple.

Extranuclear electrons already orbit nuclei; electrons have small mass but high speed. Nature uses electron motion speed to carry energy and uses different modes of electron motion to effect energy conversion (see the table below). Because the energies before and after conversion are all motions of electrons transmission and conversion from one form of electron motion to another the total remains unchanged, i.e., conservation of energy.

Energy form	**Proposed relationship to extranuclear electrons**
Thermal energy	The kinetic energy of extranuclear electrons in high-speed orbital motion at high temperature
Chemical energy	The kinetic energy of extranuclear electrons within matter at relatively high speed
Light energy	Electromagnetic waves radiated by high-speed extranuclear-electron transitions
Electrical energy	The kinetic energy of electrons in macroscopic motion under applied voltage
Mechanical energy	Macroscopic mechanical motion converted from the kinetic energy of extranuclear electrons
Bioenergy	The manifestation, within living organisms, of the kinetic energy of extranuclear electrons
Nuclear energy	The kinetic energy of nuclear microstructures (proton + electron) in ultrahigh-speed motion

Table II. Relationship between energy and extranuclear electrons

Once thought breaks free from the shackles of the "electron cloud" and "uncertainty," and focuses on the ordered motion of extranuclear electrons, the great question of energy has its answer: the energy of matter is the kinetic energy of the ordered motion of electrons; energy is contained in the speeds of ordered electron motion; energy is transmitted and converted by the motion of electrons. Aside from nuclear energy, all microscopic energies are accomplished by electron motion, and the existence and interconversion of various energies are closely tied to the motion of extranuclear electrons.

(The preceding twenty chapters did not touch on nuclear energy; thus the present discussion of energy remains confined to electrons.)

Exploring the ordered motion of extranuclear electrons reveals the connotation of material energy; the energies in the table are all kinetic energies of extranuclear electrons; different modes of extranuclear-electron motion are the internal reasons for energy conversion, transfer, storage, and conservation among materials; the ordered motion of extranuclear electrons is the nexus for energy conversion and conservation.

Why is energy conserved? Why can energy be transferred between materials, and why can forms of energy interconvert? The internal cause is electron motion. The modes, speeds, and kinetic energy of extranuclear-electron motion are the independent manifestations and the internal connections of thermal energy, light energy, chemical energy, and bioenergy; the ordered motion of extranuclear electrons is the internal cause of energy conversion and conservation.

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