

Atomic Structure

The Structure and the Cause-Mechanism of Energy Levels of Quantized Atoms

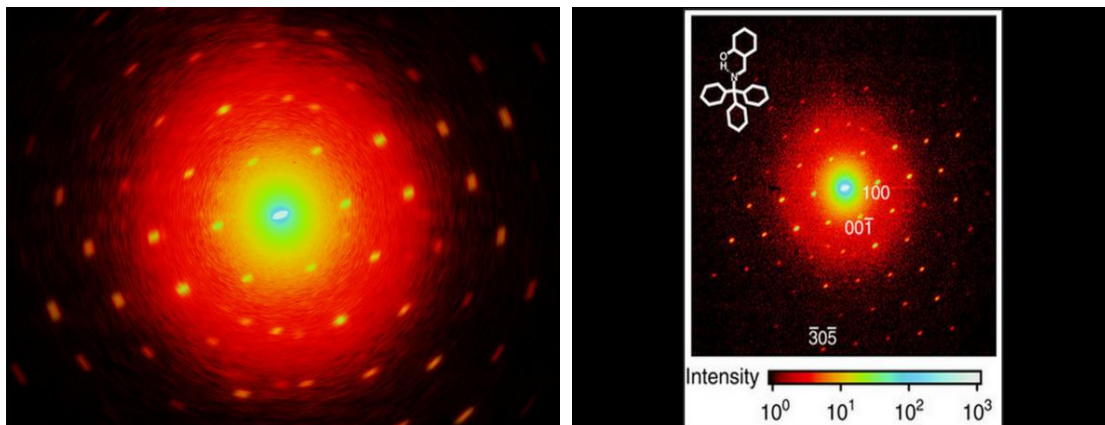
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Abstract: this article shows the atomic structure that has been proved by the related and independent experiments; Base on and combine with the atomic structure, give and show the causes and mechanism of the quantization of atomic energy levels.

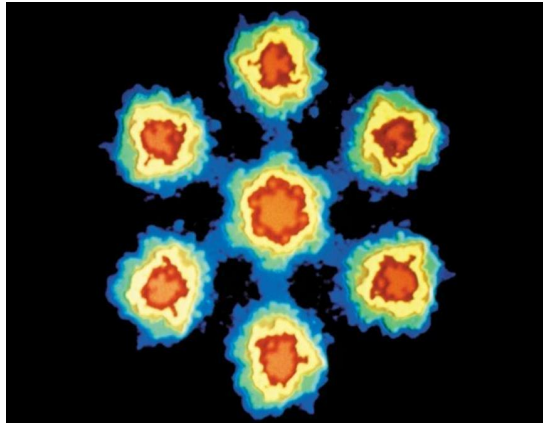
Atom, from the *Greek* word *atomos* which was first conceived around 2,400 years ago by a *Greek* man named *Democritus*, and it's means is indivisible. Atoms is the smallest constituent unit of ordinary matter that has the properties of a chemical element; even every solid, liquid and gas is composed of neutral or ionized atoms. ^[1]

Every atom is composed of a nucleus and one or more electrons being bounding together by the electric field (isn't electromagnetic field);^[1] and, the nucleus has positive electric charges, every electron has a unit negative electric charge.



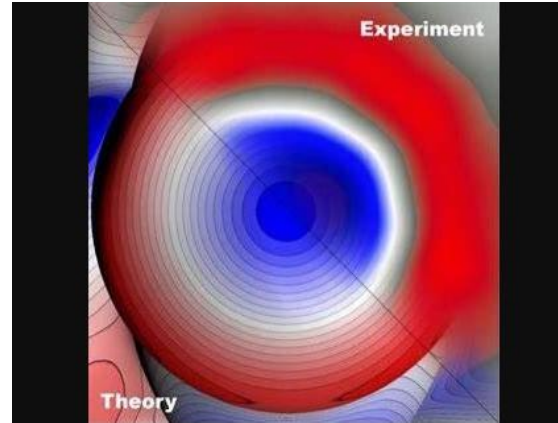
If ultrashort electron pulses hit a bimolecular crystal, they are diffracted from it. As a result, one obtains a characteristic diffraction image of the atomic structure. Credit: Graphic: Alexander Gliserin ^[11]

Within an atom, further and however, the all electrons that the all extranuclear electric charge is a continuous viscous fluid, also is one kind of soft-matter which has the same and consistent of negatively charged ingredient; is a unified and complete whole with a single basic structure, existing in and fulling completely the space which outside the nucleus of the atom; under the thermal energy effect, and by the mutual electromagnetic interaction with the nucleus and others related, Formed: the nucleus is the sphere center of atoms; different distribution of volume extranuclear electric charge densities, energy levels at and in the discrete states(energy levels quantized); from higher to lower since the inner to the outer; and with a concentric and multi-layer spherical pattern of volume extranuclear electric charge densities distribution structure and energy levels existence form. ^{[2][3][4][5][6][7][8][9][10][11][12][13]}



Scanning transmission electron microscopy image of the hexagonal arrangement of the uranium atoms in a solution of uranyl acetate.

Credit: Mitsuo Ohtsuki/SPL^[12]



Researchers have, for the first time, directly imaged a Sigma-hole, an anisotropic pattern in the electron charge distribution that surrounds certain atoms.

Credit: T. Bellon/OCB Prague^[13]

Moreover, the energy and energy levels distribution states of atoms is mainly referring to the energy and energy levels distribution states of the all extranuclear electrons – the all extranuclear electric charge which is one kind substance of *Bosons*.^[14]

Inside atoms, the all extranuclear electric charge forming a sort of *Hilbert spaces* which could be infinitely discretized and quantized in theory; the all extranuclear electric charge existing in a different density distribution state that a concentric and multilayer spherical pattern; and the densities distribution ρ is the function of the charges amount, temperature, pressure and electromagnetic strength, and there be $\rho = F(Q, T, P, E, B)$.^{[15][16][17]}

Since the volume mass densities (ρ ; *divergences*) of any two distinct extranuclear electric charge layers are different; and by the $E = mc^2$, the conclusion could be obtained that the energy which contained in every unit volumes of any two distinct extranuclear electric charge layers are also different. That is the normal frequency (natural frequency) ν and the volume energy density (the energy level $h\nu$) of any distinct extranuclear electric charge layers is all different from each other.

By the way, that there should be $E/V = mc^2/V = \rho c^2 = h\nu$, $\nu = \rho c^2/h$, and $\rho = h\nu/c^2$; but instead of $E = mc^2 = h\nu$, and $m = h\nu/c^2$. And this physical meaning shows us the relationship of the energy density ($E/V = mc^2/V = \rho c^2$) or called as energy level ($h\nu$) with to the mass density (ρ ; *divergence*) of the same space area or matter system.

Further, the energy density (energy level) not only is the quantity and share of the energy which contained or combined in the unit volume of the matter, is also the quantity and share of the matter which contained or combined in the unit volume or called as the unit space. Same time, the volume mass density of the matter is proportional to its energy density (energy level), and the volume mass density of the matter is the characterization and the manifestation of its energy density state (energy level state).

An important physical fact which needs to be clear that the energy and the matter are can't mutual transformation. The matter is the carrier and habitat of the energy, is also the result of the effect and gather of the energy; and the energy is the guarantee and support of the matter can exist and keeping its density, is also the reason and driving force of the evolutions, phase transitions, and engender physical or chemical variations of the matter.

For instance, after a polyatomic system reached its *Bose-Einstein* condensate through the first-order and second-order of quantum phase transitions by loses the thermal energy and reduces the temperatures continues (*temperature – the scale and metric of the thermal energy density of a matter system*), then, the all atoms in the system would also reached an identical and consistent state, and the all extranuclear electric charge which one kind of Bosons is forming an unified and complete whole that in an exactly the same volume mass density, and no any cracks or electron-holes inside; the mass density and the energy density (energy level) of the polyatomic system is also at an identical and consistent state which its lowest – the ground state, in the state, the all extranuclear electric charge is a volume mass density non-discretization system; is also an energy level non-quantization system. On the contrary, after obtained the thermal energy and temperature rose continue and enough, the all extranuclear electric charge of this polyatomic system would return into the normal state which the volume mass densities discretization (non-identical state that has multivariate volume mass densities) and the energy levels quantization (non-identical state that has multivariate energy levels, or said the system in a multivariate quantum state). And, there only existences the increase and decrease of the thermal energy, as well as the variations of the matter states and the mass densities; but no any increase and decrease of the ingredients and mass of the matter in the process. ^{[18][19][20]}

In physics, the energy is quantized or said as quantization of the energy, means that the volume mass densities and volume energy densities (energy levels) of the natural world or a matter system is at a discrete and non-identical state – has nonuniform volume mass densities and nonuniform volume energy densities (energy levels); corresponding, the natural world or a matter system would be at an identical and energy level non-quantized state if the volume mass density and the volume energy density (energy level) both are identical and consistent in any unit space volumes and any measure scales.

Overall and in short, the natural world is composed of the matter (elementary particles and their composite particles) and the energy (thermal energy. and the essence of light is thermal energy; light is the existence, agglomeration and excitation of thermal energy in medium; it is the self-existence of heat energy manifested through the medium; is the mutual expression and co-presentation between the heat energy and the medium), under the controls of the thermal energy and the auxiliary roles of the other effects such as electromagnetic effect, the all matter of the natural world forming a non-identical and nonuniform distribution state which has multivariate mass densities, and a non-identical and nonuniform state which has multivariate energy levels; and, the volume mass

densities are discretized and the volume energy densities (energy levels) are quantized is the existence state, even is also one kind of the basic properties of the natural world.

Besides, although the volume mass densities and volume energy densities (energy levels) of nature is discretization and quantization, however, the absorption and emission of energy is continuous within every matter system which in the same energy level. ^[21]

With regard to atoms, in particular, at their *Bose-Einstein* condensates, the extranuclear electric charge of an atom or a polyatomic system forming an unified and complete whole body that has no any cracks or electron-holes inside, and has an exactly the same volume mass density as well as an identical and consistent energy level; at the normal state, under the controls of thermal energy and the auxiliary roles of electromagnetic effect, the all extranuclear electric charge of the atom forming a non-identical and nonuniform distribution state which has multivariate mass densities, as well as a non-identical and nonuniform state which has multivariate energy levels - forming $k(\geq 2)$ matter layers that the mass densities and the energy densities are different from each other at a concentric and multilayer spherical pattern. Based on them, some conclusions would be obtained as following:

1. M is the total mass of the all extranuclear electric charge of an atom; Q is the total amount of the all extranuclear electric charge of the atom; V_o is the total volume of the all extranuclear electric charge in its *Bose-Einstein* condensate(ground state), ρ_o is the volume mass density of the extranuclear electric charge in ground state, ν_o is its normal frequency(natural frequency) in ground state, and $\rho_o c^2 = h\nu_o$ is its energy density and energy level in ground state, E_o is its total energy in ground state, and $E_o = \rho_o c^2 V_o = h\nu_o V_o = Mc^2$. And, the energy level of the all extranuclear electric charge of the atom in ground state is an identical at $\rho_o c^2 (h\nu_o)$ and is non-quantized.

2. M_i is the mass of the i -th electric charge layer; Q_i is the electric charge amount of the i -th electric charge layer; V_i is the volume of the i -th electric charge layer; ρ_i is the volume mass density of the i -th electric charge layer; ν_i is the normal frequency(natural frequency) of the i -th electric charge layer; and $i = 1, 2, \dots, k$.

(Remark: since this article mainly discusses for the basic structure of atoms, thus, in order to reach a clear and concise, the gradient of volume mass density and the fine structure of every charge layers are not have been discussed in here)

3. E_{io} is the energy density or energy level of i -th extranuclear electric charge layer, and there be $E_{io} = \rho_i c^2 = h\nu_i$; and $i = 1, 2, \dots, k$.

4. E_i is the energy of i -th extranuclear electric charge layer in the normal state, and then there be $E_i = M_i c^2 = \rho_i c^2 V_i = h\nu_i V_i$; and $i = 1, 2, \dots, k$.

5. E is the total energy of the all extranuclear electric charge of the atom in the normal state, then there be

$$E = E_1 + E_2 + \dots + E_k = h\nu_1 V_1 + h\nu_2 V_2 + \dots + h\nu_k V_k = \rho_1 c^2 V_1 + \rho_2 c^2 V_2 + \dots + \rho_k c^2 V_k = Mc^2.$$

$$E = Mc^2 = E_o = \rho_o c^2 V_o = h\nu_o V_o; \quad M_i = \rho_i V_i; \quad 0 < M_i < M, \quad 0 < Q_i < Q, \quad 0 < V_i < V_o;$$

$$M_1 + M_2 + \dots + M_k = M, \quad Q_1 + Q_2 + \dots + Q_k = Q, \quad V_1 + V_2 + \dots + V_k < V_o;$$

$$\rho_i > \rho_o, \quad \nu_i > \nu_o, \quad \rho_i c^2 (h\nu_i) > \rho_o c^2 (h\nu_o); \quad \text{and } i = 1, 2, \dots, k.$$

These above results shows that increase external energy can't change the innate energy of the all extranuclear electric charge, but can changes the distribution states of the volume mass densities and energy densities of the all extranuclear electric charge – making the all extranuclear electric charge is separated from a single complete and density consistent state into a concentric and multilayer pattern which having different volume mass densities and different energy densities; this is made the extranuclear electric charge into the state which matter distribution diversification, volume mass densities discretization and energy levels quantization, and their degrees of quantities and levels both are proportional and synchronous to the intensity and level of the external energy. ^{[15][22]}

Same time, every extranuclear electric charge layer, forming a fundamental field; k electric charge layers formed k fundamental fields. All particles produced from the same electric charge layer are identical particles which their energy levels are all $E_{i0} = hv_i$ and $i=1,2,\dots,k$; or is an identical energy flow which its energy level is $E_{i0} = hv_i$ and $i=1,2,\dots,k$.

Every extranuclear electric charge layer uniquely corresponds to one spectral line; k electric charge layers correspond to k spectral lines, and the frequency of the spectral line which corresponds to i -th electric charge layer is ν_i and $i=1,2,\dots,k$.

On the contrary, if there be k spectral lines, should corresponding to be the existence of k different electric charge layers; if the frequency of a spectral line is ν_i , then, the electric charge layer which corresponding and emitting to the spectral line should be i -th electric charge layer and its normal frequency (natural frequency) is ν_i and $i=1,2,\dots,k$.

References

- [1] Atom
<https://en.wikipedia.org/wiki/Atom>
- [2] A new model of atomic structure
<http://vixra.org/abs/1401.0147>
- [3] Defining and delimiting of the elementary particle
<http://vixra.org/abs/1610.0177>
- [4] The electron beam passes through a screen and is transformed into a vortex beam
<https://www.sciencedaily.com/releases/2012/11/121105100845.htm>
- [5] Electron microscopes with a twist
http://www.tuwien.ac.at/en/news/news_detail/article/7826/
- [6] For the First Time: Electrons are Imaged Flowing Like Water
<https://www.weizmann-usa.org/news-media/news-releases/for-the-first-time-electrons-are-imaged-flowing-like-water>
Visualizing Poiseuille flow of hydrodynamic electrons.
Nature, 2019; 576 (7785): 75 DOI: 10.1038/s41586-019-1788-9
- [7] Seeing is believing: precision atom qubits achieve major milestone
<https://newsroom.unsw.edu.au/news/science-tech/seeing-believing-precision-atom-qubits-achieve-milestone>
Two-electron spin correlations in precision placed donors in silicon
Nature Communications (2018). DOI: 10.1038/s41467-018-02982-x
- [8] Artificial intelligence improves control of powerful plasma accelerators
<https://www.imperial.ac.uk/news/210313/artificial-intelligence-improves-control-powerful-plasma/>
Automation and control of laser wakefield accelerator using Bayesian optimization
Nature Communications (2020). DOI: 10.1038/s41467-020-20245-6
- [9] Electrons that flow like water are just the beginning
<https://seas.harvard.edu/news/2020/09/electrons-flow-water-are-just-beginning>
Imaging phonon-mediated hydrodynamic flow in WTe₂
Nature Physics 17, 1216–1220 (2021). DOI: 10.1038/s41567-021-01341-w
- [10] Electrons that flow like liquids pave the way for robust quantum computers
<https://www.ntu.edu.sg/research/research-hub/news/detail/electrons-that-flow-like-liquids-pave-the-way-for-robust-quantum-computers>
Tuning the many-body interactions in a helical Luttinger liquid
Nature communications(2022). DOI:10.1038/s41467-022-33676-0
- [11] Film production in 4D with ultrashort electron pulses
<https://www.mpg.de/5249324/15-10-27-film-production-in-4d-with-ultrashort-electron-pulses>
Sub-phonon-period compression of electron pulses for atomic diffraction
Nature Communications, 27. October 2015, DOI: 10.1038/ncomms9723
<https://www.nature.com/articles/ncomms9723>

- [12] *Fire up the atom forge*
Nature 539, 485–487 (2016). DOI: 10.1038/539485a
<http://www.nature.com/news/fire-up-the-atom-forge-1.21017>
- [13] *Real-space imaging of anisotropic charge of σ -hole by means of Kelvin probe force microscopy*, *Science* 374, 863–867 (2021). DOI: 10.1126/science.abk1479
<https://www.science.org/doi/10.1126/science.abk1479>
- [14] *Energy level*
https://en.wikipedia.org/wiki/Energy_level
- [15] *Quantum Hilbert Hotel*
<https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.115.160505>
- [16] *Weird new electron behaviour in stacked graphene thrills physicists*
<https://www.nature.com/articles/d41586-024-00939-3>
- [17] *Volume charge density functional theory (VDFT)*
<https://vixra.org/abs/1404.0084>
- [18] *The structure, state and properties of matter in Bose-Einstein condensate*
<http://vixra.org/abs/1509.0184>
- [19] *Quantum phase transition and quantum critical point*
<http://vixra.org/abs/1510.0077>
- [20] *The structure of graphene*
<http://vixra.org/abs/1511.0045>
- [21] *The light*
<http://vixra.org/abs/1605.0250>
- [22] *Observation of optomechanical strain in a cold atomic cloud*
<https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.119.163201>

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