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On Some Considerations of Cloud Particles and Photons Interaction

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ABSTRACT

The interaction of light (photon) and cloud particles according main quantum assumption that system internal energy is composed by bound microparticles (cluster) under certain conditions can obtain allowed discrete significances has been discussed in the article. The objective is to calculate the transition probability from one state into another caused by inner forces or any internal processes. The cluster may be presented as multipole system. The some peculiarities of microstructure of cloud formations have been discussed using quantum disperse forces or Van-Der-Vaals forces that are typical for water particles. To obtain the expression for interaction potential the wave functions of basic and exited states of clusters and dispersion matrix have been introduced describing by virtual photon. It has been turned out that virtual photon interaction causes potential holes and barriers that are decreased by height and width. The isolated long wave quant may be the radiation that is generated throughout observed microphysical processes.

Key Words: *Water molecule, photon exchange, interaction potential, probability amplitude, wave function.*

Introduction

Water is a compound and polar molecule, which is liquid at standard temperature and pressure. It has the chemical formula H_2O, meaning that one molecule of water is composed of two hydrogen atoms and one oxygen atom. Water is found almost everywhere on earth and is required by all known life. About 70% of the Earth's surface is covered by water. The important feature of the water molecule is its polar nature. The water molecule forms an angle with hydrogen atoms at the tips and oxygen at the vertex. Since oxygen has a higher electronegativity than hydrogen, the side of the molecule with the oxygen atom has a partial negative charge. Usually the molecule with such charge difference is called a dipole. The charge differences cause water molecules to be attracted to each other and to other polar molecules. This attraction is known as hydrogen bonding. This bonding gives water unusual properties. Many studies and experiments with HT equipments are made to understand water properties [1].

The interaction of light (photon) and cloud particles according main quantum assumption that system internal energy is composed by bound microparticles (cluster) under certain conditions can obtain allowed discrete significances has been discussed in the article. The objective is to calculate the transition probability from one state into another caused by inner forces or any internal processes. The cluster may be presented as multipole system. The multipole is the system composed by couple opposite charges that have definite symmetry type. The simplest is the dipole. If the transition is forbidden in dipole approach it may happen in higher approaches – quadrupole (electric) or magnetic dipole. Their probability is approximately 10^6 times less than dipole. To search out transition probability of cluster from basic state into exciting or virtual one interacting with electromagnetic field the identification of Einstein factors have to be needed [2,3].

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holes and barriers that are decreased by height and width. The isolated long wave quant may be the radiation that is generated throughout observed microphysical processes.

Methods

The water H_2O is the molecule everybody knows and life is impossible without it. But for all its familiarity and import for life, aspects of water's behavior have been hard to understand, including its transformation in cloud medium.

Meteorology is an extraordinarily interdisciplinary subject, with quantitative links to many of the applied sciences and now in presented paper cloud medium is discussed using quantum theory.

Microparticles are described using wave function in quantum mechanics. The quantum system state is considered defined if its wave function (Schrödinger) or ket-vector (Dirac) is given.

The system energy change comes with quantum transportation from one energetic level into another. If $E_1>E_2$ than system emits energy equal to E_1-E_2 and if $E_1>E_2$ then absorbs. Such transportations happen while interaction with electromagnetic radiation. Emitted or absorbed photon energy is defined by Bohr frequency law:

$$\hbar w_{12} = |E_2 - E_1| \qquad (1)$$

Molecules full energy may be presented by the kinetic energy sum connected with mass center and by internal energy sum. Molecules energy may be considered as compound from three parts:

1. Electron energy connected with their rotation around nuclei
2. E_{os} – oscillation energy connected with nuclear vibration towards mass center
3. E_{rot} –rotation energy connected with molecules rotation towards mass center

Diatomic molecule rotates around mass center located on symmetry axis of molecule. Rotation energy is defined as:

$$E_{rot} = \hbar^2 \frac{K(K+1)}{2I} = BK(K+1) \qquad (2)$$

where $I=MR_o^2$ inertial moment;

B- rotation constant;

K=0, 1, 2, 3 rotation quantum number

$|M_{rot}| = \sqrt{K(K+1)\hbar}$ - impulse momentum of rotation

Vibration energy may be defined as following

$$E_{os} = \hbar w_0 (q + \tfrac{1}{2}) - \hbar w_0 \kappa (q + \tfrac{1}{2})^2 \qquad (3)$$

where $\kappa = \frac{\hbar w_0}{4D} << 1$ –is nonharmonic constant.

Characterization of electric terms doesn't differ from diatomic molecule terms. In molecule nucleus electic field have no central symmetry thus the full orbital moment haven't been kept. In diatomic molecule the electric field has axial symmetry and in this case the component on the axis passing through the nucleus of orbital momentum has been kept. It is called molecule orbital quantum number and gets discrete values 0,1,2,...

Molecule state is also chracterized by full electron spin S and it has internal quantum number $\Omega = \Lambda + S$

The light is considerd as the combination of photons with ka state and $-\hbar w$, $\hbar k$ impulses. Photon or molecular system interaction happens by forming or disappearance of light quants. During this process energy and impulse are keeping. Quantum trasformation is system trasportation from one energetic state into another. The task is to identify transformation probability from one energetic state into another. Clusters may be presented as multipole systems. Multipole is the system compound from couple of opposite charges, obtaining definite symmetry. The simpliest is dipole. If transpostation is prohebitated in dipole approach it may happen in higher approach – quadropole (electric) or magnetic dipolic.

Their probability is 10^6 time less than dipole. To identify transportation probability the Einstein members have to be defined according clusters properties. Spontaneous and forced motion members may be identifies.

Quantum transition combination is characterized by D_{mn} numbers two dimensional unity and is infinite matrix:

$$\begin{Vmatrix} D_{11,}D_{12},.....D_{1n}.... \\ D_{21},D_{22},...D_{2n}.... \\ ..... \\ D_{n1},D_{n2},...D_{nn}... \\ ..... \end{Vmatrix}$$

where $D_{mn}^0 = e\int_v \psi_m^* \vec{r}\,\psi_n dv$

is dipole transition matrix element

The nondiagonal matrix elements are time functions and corresponds light absorption or emitting by those frequencies defined from Bohr frequency selection low.

And Einstein members can be defined as for spontaneous and forced transition probabilities:

$A_{mn} = \frac{w_{mn}^3}{3q_0\pi\hbar c^3}(D_{mn})^2$ - spontaneous transition probability

$B_{mn} = \frac{\pi}{12q_0\hbar^2}(D_{mn})^2$ -forced transition probability

Amn is approximately 10^8 sec $^{-1}$

If some matrix element equals 0 it is called prohibited then this transition doesn't happens in dipole approach and happens in magnetic. If transitions are prohibited or banned for clusters higher energetic level the lower energetic level is called metastable and clusters life duration is 10^{-3} sec. or more.

If transition is allowed in dipole approach then system life duration is of spontaneous transition probability order. If transition is banned in dipole approach or $D_{mn}=0$ it doesn't mean that it haven't happen generally as cluster has electric quadruple or magnetic dipole moment. If transition is banned for clusters high energetic level than lower level in electric dipole interactions is called as metastable level. In this clusters life duration is 10^{-3} sec or more. In first quantum transition approach there acts Bohr prohibition principle. If such transition still happens it would be on the second or higher approach order and probability will be also less. Such are light scattering in viscous medium, mist, aerosols and etc.

This process on molecular level happens as follows: if outer emitting frequency differs from absorption frequency energy quant is anyway transmitted to the cluster which transforms into virtual state with short life period and will be defined from the uncertainty principle. Then it emits same frequency photon and returns at initial state. I definite conditions cluster may transform into final state from virtual. I simple case the falling wave is flat and emitted spherical. Energy and impulse are kept as usual except virtual state, when energy isn't keeping. For those transitions it is necessary that the electron-photon interaction matrix element have to be differs from 0.

In definite conditions cluster may transform from virtual into final state that will be differ from initial. Also emitted photon has different polarization and frequency.

In second approach it is possible the existence of two photon absorption process. After absorbing photon system transits into virtual state where it absorbs another photon and then transports into stationary state

In classical mechanics, the possible states of system S are all positive normalised functions (Distribution function) on the phase space P and possible observables are all real function on P. P is fixed and uniquely associated with the system alone and forms the basis of this kinematic description. Hence, transitions between different sets of observables similar to those described above would be impossible in classical mechanics. They are only enabled in quantum mechanics by the non-objective character of observables: not only their values cannot be ascribed to microsystem S alone but some of them are not even

registrable in principle due to external conditions in which S is. It is assumed that the quantum kinematics of a microsystem is defined mathematically by the possible states represented by all positive normalised (trace one) operators, and possible observables represented by some self-adjoint operators, on the Hilbert space associated with the system. Then the transitions of states and observables that go with changes of separation status cannot be viewed as a part of a dynamical trajectory due to some new version of the dynamics of S, but as a change of its kinematic description. Thus, although the change of separation status is similar to the collapse of the wave function (the non-local character included), it is both more radical and better understood.

On Earth the dimpliest and common is water molecule that has essential significance in existence of organ and nonorganic life. The most of its properties are preconditioned by the fact that three component atoms aren't placed on one line. Negative charge prevailed on oxygen atoms part and positive on hydrogen. Thus water molecule is electrically polarized. The cloud properties and their stability may be explain from water molecules properties and characterizing forces that reach maximum for 1micro-meter particles and are separated from each other on 50km distance

The comparison between the experimental and calculated molecular dipole moments is difficult, as the experiments are measuring the dipole moment in the vibrational ground state $\mu 0$, whereas the calculations are carried out for the equilibrium dipole moment μe, and thus we would have to carry out a vibrational averaging in order to speak of the same quantity. However, there are a few experimental values for μe. However it is estimated as H_2O= 1.8473(10) [6,7].

For the total molecular energy, i.e., *E* in the molecular SchrÄodinger equation, there is no experimental counterpart. and we examine it in order to establish a feeling on the severity of the approximations involved in the calculation. We should recall that there were a third class of approximations in addition to the truncation of one- and *N*-electron spaces: approximations in the molecular Hamiltonian ^*H* . To investigate the validity of the use of the non-relativistic Hamiltonian, we include the leading-order one-electron relativistic corrections that include the spin-orbit interaction (SO), mass-velocity (MV), and the Darwin (Dar) corrections. The leading-order two-electron contributions, such as the two-electron Darwin contribution and the spin-spin contact interaction, are smaller by at least one order of magnitude. The MV and Dar corrections are always of opposite sign. The calculation is carried out using the CCSDT model for the water molecule in the cc-pCV*X*Z bases, at a CCSD(T)/cc-pCVQZ geometry [6,7].

Total energy [*Eh*]

	CCSDT	HF
DZ	-76.24121	-76.02680
TZ	-76.33228	-76.05716
QZ	-76.35981	-76.06482
5Z	-76.36899	-76.06708

Among atoms and molecules acts force that always has attractive character. It is intermolecular dispersive or Van-Deer-Vaalse force. It is only one of the expressions of electromagnetic force. It acts among electrically neutral systems such as dipole or quadruple. In dipoles force reduces by r^4 inverse proportional and in quadrupole by r^{-6}. It is not temperature dependent and it s nature is quantum [8,9]. By increasing dipole number their interaction increases. But its interaction is limited by the matter that light speed is finite

For cluster stable and exiting states wave function $\Psi = \Psi(x, y, z, t)$ have been used. Its physical essence is that it is particle detection probability in d_v volume for t time moment.
Probability is defined as

$$W = \left|\Psi(x, y, z, t)\right|^2 = \Psi^*\Psi \qquad (4)$$

Ψ^* is complex conjugated quantity of Ψ .

$\int_v \left|\Psi(x, y, z, t)\right|^2 dv = 1$ - is rationing condition and Ψ function that assure this condition standardized.

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Generally it is expressed as:

$$\Psi(x, y, z, t) = \iiint \varphi(P_x, P_y, P_z, t) \exp(i \tfrac{px+py+pz}{h}) \tfrac{dp_x dp_y dp_z}{(2\Pi\hbar)^{3/2}}, \quad (5)$$

Suppose φ_1, φ_2 are clusters basic and exited states wave functions. Their interaction in lower approach is descriped by so called scattering matrix

$$\varphi(x,t) = \widehat{S}(t, t_0)\varphi(x, t_0), \quad (6)$$

where

$\widehat{S}(t, t_0) = \exp(-\frac{i}{\hbar}\widehat{H}(t - t_0))$.

$\widehat{H}$ is system Hamiltonian. The matrix elements of scattering operator define transition probability from initial quantum state into another.

$$S_{if} = -i \int d\vec{r}_1 d\vec{r}_2 dt \varphi_1^* \varphi_2 U(r) \varphi_2 \varphi_1 \exp(-i(E_{1i} + E_{2i} - E_{1f} - E_{2f})t),$$

where $E_i E_f$ is clusters basic and final states kinetic energies.

The interaction potential may be connected with averaged scattering matrix that is described by one-photon resonant exchange Hamiltonian

$$H = -\vec{d}_1 \vec{E}_1(r) - \vec{d}_2 \vec{E}_2(r)$$

where $\vec{d}, \vec{E}$ are dipole moment and field tension operators. Then for potential the following is obatained:

$$U(\vec{r}) = \tfrac{i}{4\Pi} \int_{-\infty}^{\infty} d\omega \omega^2 \alpha_{ik}(\omega) D_{ik}(\omega, \vec{r}), \quad (7)$$

Where D_{ik} is photon Green function and

$$\alpha_{ik} = \tfrac{1}{3}\delta_{ik} \sum_n |d_n|^2 \left[(\omega_n - \omega - i\Gamma_n)^{-1} + (\omega_n + \omega - i\Gamma_n)^{-1}\right], \quad (8)$$

is the polarization tensor.

After integration (7) considering (8) the following expression is obtained for potential

$$U(r) = -\tfrac{2}{3c^2} \sum_n r_n^{-1} |d_n|^2 \omega_n^2 \exp(\tfrac{\Gamma_n r}{c}) \cos \tfrac{\omega_n r}{c}. \quad (9)$$

In equation summarization occurs for all levels.

Conclusion

The century long of theoretical research and the on-going revolution in computer technology have made quantum mechanics applicable to small molecules, where quantum-mechanical calculations have reached the accuracy that challenges experimental results. However, limitations of existing quantum mechanical methods to describe the large molecular systems, that modern molecular science often deals with, is real obstacle to forth going. The extremely different approaches must be taken to describe such systems [10,11, 12].

Thus one photon resonance exchange creates decreasing potential holes by height and depth. From this expression may be obtaied solution for isolated long-wave radiation potentials. isolated long-wave quants may be the radiation which happens when on cluster surface or cristallyne lattice additional molecule enters or in drop while molecule difussion [12.13].

During cristalization and condensation the some portion of latent heat may be trasformed in characterized radiation. The transformation energy is distributed between existed and new energetic levels. They are called as phase radiation and is depended on medium optical properties. The cloud medium may be imagined as unity of clusters that are on different energetic levels, interacting through energy emition-absorbtion. According to this Earth surrounding environment is one of possible renewable energy source [14], the use of which gives chanse on transition into new energy transportation means.

References

[1] Direct observation of ultrafast hydrogen bond strengthening in liquid water". Jie Yang, Riccardo Dettori, J. Pedro F. Nunes, Nanna H. List, etc. Nature, 2021, DOI: 10.1038/s41586-021-03793-9

[2] Landau L.D., Lifshic E.M. Quantum Mechanics. v.3. 1989

[3] Perelman M.E., Badinov I.Ia. Model of cloud formations. Bulletin of Georgian Acedemy of Sciences, v.131, N2, 1988

[4] Hasted D. Physics of atomic collisions. 1965

[5] Tatishvili M. Some peculiarities of mathematical simulation of cloud microstructure. Transactions of the Institute of Hydrometeorology, v.114, 2009.

[6] Baur G. et al. Nuclear Physics, A 729, 2003, pp. 787–808

[7] Pekka Manninen. manninen@chem.helsinki.fi http://www.chem.helsinki.fi/»manninen/mqm06.html

[8] Tatishvili M. Energy transformation in clouds according quantum principles. International Scientific Journal. Journal of Environmental Science, vol. 3, 2014, pp. 7-9.

[9] Tatishvili M. Developing Weather Forecasting System in Georgia. Ecology & Environmental Sciences, 2 (7), 2017, DOI:10.15406/mojes.2017.02.00046

[10] Selvam A. M. A General Systems Theory for Chaos, Quantum Mechanics and Gravity. Apeiron 11, 134-146, http://redshift.vif.com/JournalFiles/V11NO3PDF/V11N3SEL.PDF
http://arxiv.org/html/physics/0211066, 2004

[11] Palmer T.N. Quantum Reality, Complex Numbers and the Meteorological Butterfly Effect. European Centre for Medium-Range Weather Forecasts Shinfield Park, RG2 9AX, Reading .UK. Bulletin of the American Meteorological Society", April 2005

[12] Hajcek P. A new approach to quantum measurement problem: cluster separability. Journal of Physics: Conference, Series 306**,** 2011, 012035 doi:10.1088/1742-6596/306/1/012035

[13] Tatishvili M.R., Palavandishvili A.M. Impact of Short-Term Geomagnetic Activity on Weather and Climate Formation in Georgian Region. Journal of the Georgian Geophysical Society,Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, ISSN: 1512-1127, v. 23(2), 2020.

[14] Tatishvili M.R., Khvedelidze Z.V., Demetrashvili D.I. On some weather forecasting models in Georgia. Journal of the Georgian Geophysical Society, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, . ISSN: 1512-1127, v. 23(2), 2020.

ღრუბლის ნაწილაკების და ფოტონების ურთიერთქმედების ზოგიერთი მოსაზრების შესახებ

მ. ტატიშვილი

რეზიუმე

სინათლის (ფოტონის) და ღრუბლის ნაწილაკების ურთიერთქმედება ძირითადი კვანტური დაშვების მიხედვით, რომ სისტემის შიდა ენერგია შედგება ბმული მიკრონაწილაკებით (კლასტერი) გარკვეულ პირობებში, რომლითაც შესაძლებელია მათთვის დაშვებული დისკრეტული მნიშვნელობების მიღება, განხილულია სტატიაში. კვლევის მიზანია გამოვთვალოთ ერთი მდგომარეობიდან მეორეში გადასვლის ალბათობა, რომელიც გამოწვეულია შინაგანი ძალებით ან რაიმე შინაგანი პროცესებით. კლასტერი შეიძლება წარმოდგენილი იყოს როგორც მრავალპოლუსიანი სისტემა. ღრუბლოვანი წარმონაქმნების მიკროსტრუქტურის ზოგიერთი თავისებურება განხილულია წყლის ნაწილაკებისათვის დამახასიათებელი კვანტური დისპერსიული ძალების ან ვან-დერ-ვაალსის ძალების გამოყენებით. ურთიერთქმედების პოტენციალის ფორმულის მისაღებად შემოტანილია კლასტერის ძირითადი და ბოლო მდგომარეობების ტალღური ფუნქციები და დისპერსიული მატრიცა, რომელიც აღწერს ვირტუალურ ფოტონს. აღმოჩნდა, რომ ვირტუალური ფოტონის ურთიერთქმედება იწვევს პოტენციურ ხვრელებსა და ბარიერებს, რომლებიც სიმაღლის და სიგანის მიხედვით მცირდება. იზოლირებული გრძელი ტალღის რაოდენობა შეიძლება იყოს რადიაცია, რომელიც წარმოიქმნება დაკვირვებადი მიკროფიზიკური პროცესების განმავლობაში.

О некоторых соображениях взаимодействия облачных частиц и фотонов

М.Р. Татишвили

Резюме

В статье обсуждается взаимодействие света (фотона) и облачных частиц в соответствие с основным квантовым предположением о том, что внутренняя энергия системы состоит из связанных микрочастиц (кластера), которые при определенных условиях могут принимать разрешенные дискретные значения. Цель состоит в том, чтобы рассчитать вероятность перехода из одного состояния в другое, вызванное внутренними силами или какими-либо внутренними процессами. Кластер можно представить как многополюсную систему. Некоторые особенности микроструктуры облачных образований обсуждались с использованием квантово-дисперсных сил или сил Ван-дер-Ваальса, характерных для частиц воды. Для получения выражения для потенциала взаимодействия введены волновые функции основного и возбужденного состояний кластеров и дисперсионной матрицы, описываемые виртуальным фотоном. Оказалось, что взаимодействие виртуальных фотонов вызывает потенциальные ямы и барьеры, которые уменьшаются по высоте и ширине. Изолированный длинноволновый квант может быть излучением, генерируемым во время наблюдаемых микрофизических процессов.