

ON THE WATER QUANTUM PROPERTIES IN METEOROLOGY

Tatishvili M.

*Institute of Hydrometeorology of Georgian Technical University, Tbilisi, Georgia
m.tatishvili@gtu.ge*

Summary: *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: *Quantum transportation, interaction potential, cloud medium, dispersion matrix, microphysical processes.*

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].

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.

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 $E_1 > E_2$ then 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:

$$\hbar\omega_{12} = |E_2 - E_1| \quad (1)$$

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:

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

where $I = MR_0^2$ 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

$$E_{os} = \hbar\omega_0 \left(q + \frac{1}{2}\right) - \hbar\omega_0 \kappa \left(q + \frac{1}{2}\right)^2 \quad (3)$$

where $\kappa = \frac{\hbar\omega_0}{4D} \ll 1$ – is nonharmonic constant.

Characterization of electric terms doesn't differ from diatomic molecule terms. In molecule nucleus electric 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 characterized by full electron spin S and it has internal quantum number $\Omega = \Lambda + S$

The light is considered as the combination of photons with ka state and $-\hbar\omega, \hbar k$ impulses. Photon or molecular system interaction happens by forming or disappearance of light quants. During this process energy and impulse are keeping. Quantum transformation is system transportation 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 simplest is dipole. If transportation is prohibited 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_{mm} numbers two dimensional unity and is infinite matrix:

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

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

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 law.

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

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

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

A_{mn} 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

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

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. 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

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

Ψ^* is complex conjugated quantity of Ψ .

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

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

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

Ψ^* is complex conjugated quantity of Ψ .

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

Generally it is expressed as:

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

Suppose φ_1, φ_2 are clusters basic and exited states wave functions. Their interaction in lower approach is described 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 obtained:

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

Where D_{ik} is photon Green function and

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

is the polarization tensor.

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

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

In equation summarization occurs for all levels.

Conclusion

Thus one photon resonance exchange creates decreasing potential holes by height and depth. From this expression may be obtained solution for isolated long-wave radiation potentials. Isolated long-wave quanta may be the radiation which happens when on cluster surface or crystalline lattice additional molecule enters or in drop while molecule diffusion [5,6].

During crystallization and condensation the some portion of latent heat may be transformed 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 emission-absorption. According to this Earth surrounding environment is one of possible renewable energy source [8], the use of which gives chance on transition into new energy transportation means.

References

1. Yang J., Dettori R., Nunes J.P.F., List N.H., etc. Direct observation of ultrafast hydrogen bond strengthening in liquid water. // *Nature*, 2021, DOI: [10.1038/s41586-021-03793-9](https://doi.org/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 Academy of Sciences*. v. 131, N 2, 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, (in Georgian).
6. Tatishvili M. Energy transformation in clouds according quantum principles. // *International Scientific Journal, Journal of Environmental Science*, vol. 3, 2014, pp. 7-9.
7. Developing Weather Forecasting System in Georgia. // *Ecology & Environmental Sciences*, 2(7), 2017, DOI:10.15406/mojes.2017.02.00046
8. 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.
9. 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.