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A Hidden Variable Model of Nuclear Reactions

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Abstract - *We propose a deterministic framework of nuclear reactions based on a generalization of two previous tentative infinite dimensional hidden variable models of the author which were applied to Hydrogen stationary atomic spectra and atomic quantum jumps. We conceive the nucleon as an open system immersed in a polarized vacuum; we therefore modify the Gamow nuclear tunneling transition probabilities making them dependent on a hidden vacuum index of refraction. We illustrate our selfconsistent model based on two equations coupling the vacuum index with nuclear electromagnetic potentials. We describe then a non Hamiltonian classical approach to the microscopic dynamic of internucleon interactions. We deduce some formulas that allow to calculate nuclear mass variation and electromagnetic emitted radiation during nuclear decays. We therefore explain nuclear decays as phenomena caused by a hidden deterministic nuclear dissipative force , that we suggest to interprete as a vacuum friction force of the polarized excited nucleus. We propose an iterative method to solve the equations of our model aimed to predict nuclear fission time and to explain the microscopic nuclear dynamics by fluctuating classical nuclear electromagnetic potentials. Finally we briefly resume our critiques to the standard description of nuclear processes based on Quantum Mechanics formalism and its successful predictive power based on stationary statistical averages .*

Keywords — *hidden variable model, time dependent transition probabilities, nuclear electromagnetic potentials, vacuum index, nuclear dissipative electromagnetic forces.*

I. INTRODUCTION

At the end of the 19^{th} century the experiments on radioactivity and alpha particle emissions inspired the Rutherford atom model, in this model the atom is composed by a charged nucleus surrounded by rotating electrons.This hypothesis together with the experimental observed discretized atomic spectra were exploited by Bohr to formulate his atomic model, based on the postulate of quantum jumps between stationary individual atomic states.

This hypothesis was at the heart of the epistemological approach developed subsequently by Bohr to quantum physics called Copenhagen School [1], that has been considered till now the standard formulation of quantum mechanics. Bohr and his famous followers as Heisenberg, Pauli and Jordan believed it was impossible to look for a classical space time descriptions of atomic transitions and consequently of nuclear reactions and assumed, on the contrary that it was meaningful only to elaborate just a statistical descriptions of microscopic quantum phenomena.

In particular it was assumed as a dogma that the atomic make instantaneous energetic tramsitions, the quantum jumps, even if it was known to be irrealistic to treat the atom as stationary isolated system; a similar dogmatic and irrealistic approach was adapted to explain nuclear dynamics and only recently has been rediscovered the relevance, for example, of the old problem of measuring the duration of a fission process [2] and the necessity to develop a theoretical prediction of the fission time.

Curiously the most famous antagonists of the Copenhagen school, as Einstein, DeBroglie, Schrodinger and Bohm didn't attack the idea of intrinsic impossibility to have a space time description of nuclear reactions and in particular no one argued against Gamow explanation of nuclear reactions by quantum tunneling probabilities [3].

Conequently, since then, nuclear reactions dynamics has been described assuming ground state stability and stationary transition probabilities and cross sections of individual quasistationary solutions of Schrodinger equations; therefore, it has been abandoned the search of a realistic and deterministic description of these processes based on real non conservative electrodynamic forces of accelerated nuclei.

To illustrate our realistic approach, we consider as an example the non inertial effect on quantum tunneling, to generalize the formula of the barrier penetration probability described in a recent review article on spontaneous fission [4]. It is calculated by the nuclear tunneling effect decribed by the standard Gamow formula

$$P = (1 + \exp[2S(L)])^{-1} \qquad (1)$$

with $S(L)$ given by

$$S(L) = \int_{Sin}^{Sout} \frac{1}{h} \sqrt{2M_{eff}(s)(V(s) - E_0)}\, ds, \qquad (2)$$

where $V(s)$ is the potential average energy and the effective mass $M_{eff}(s)$ is the collective nucleon inertia.

We notice that, even if the nucleons are accelerated interacting systems, is not discussed the possible dependence of the potential on nucleon average acceleration $V(a)$ or on the effective vacuum index induced by acceleration $V(n(a))$, that, we suggest, could be introduced in formula (2) to generalize the probability transition of formula (1).

Our impression is that notwithstanding at least a century of efforts of great scientists on nuclear physics it is still missing a theoretical microscopic model of nuclear dynamics which justify the renewed great debate and critique to the different phenomenological model used so far. In particular the nuclear liquid model and the adiabatic hypothesis , based on a collective state description of nuclear reactions, have been proven inadequate [2]. In fact we think that, even the most successful and reliable model elaborated till now, the TDDFT model [5], it is not rigorous since there is at the moment no demonstration of the unicity and the stability, for time dependent interactions of the ground state of the many body Schrodinger equations. Therefore the difficulties of the standard approaches stimulate new interest on the elaboration of more accurate realistic models of microscopic nuclear dynamics [6] ,[7], [2]. These recent interesting papers justify, we think, the search of infinite dimensional hidden variable models of nuclear reactions

. Overmore some new experiments, as those one concerning the neutron emission induced by acceleration and nuclear fission induced by intense laser pulses [8], [9], suggest a possible general phenomenon of environment induced nuclear reactions. These new phenomena urge for new theoretical models that goes beyond the standard Hamiltonian formalism of Quantum Mechanics and its prediction of stationary nuclear decays rates.

A similar interesting discussion is growing in the scientific community about the time variability of nuclear decay rates and the isotropy of the emitted radiation [10]. In the following paragraph we will expose our deterministic approach to nuclear reactions based on a generalization of an idea contained in two previous paper of the author [11], [12] regarding an hidden variable model of atomic states and atomic transitions.

We conceive the dynamics of single nucleons as open systems interacting continuously with a dynamic polarized vacuum, in analogy with a recent proposal [13]. Consequently we look at the single excitation of a pulsating nucleus with space time dependent charges, as time dependent non instantaneous analogues of atomic quantum jumps.

We try to describe nuclear dynamics as caused by a hidden electrodynamic pilot wave, that is a selfconsistent average classical wave propagating in an polarized fast fluctuating vacuum described by space time dependent vacuum index of refraction, that is the infinite dimensional hidden variable of our model.

We propose to couple the nuclear electromagnetic fields with this vacum index and to describe the nuclear excitations in a similar way to space time dependent atomic transitions. We then apply this deterministic approach to calculate the mass variation in a nuclear reaction, caused by a generalization of recently discussed vacuum friction force [14] and the theoretical electromagnetic radiation emitted.

We suggest an iterative approximate method to solve the selfconsistent equations which could be useful for predicting theoretical model of fission dynamics and accurate dynamic calculate of nuclear mass defect.

Endly we want to remark that nuclear reactions concern quantum extended systems in accelerated frame and cannot be described, we think, by relativistic generalizations of the formalism of Quantum Mechanics; in fact we think that even nucleon spin and nucleon entaglement could be explained as emergent properties of hidden path memory dependent interactions, generalizing, for example, the velocity dependent Weber forces or the volume dependent Bjerknes acoustic forces.

II. MODEL

We assume that the dynamic of a decaying nucleus is perturbed by environment dependent vacuum polarization and can be described by a generalization of a deterministic framework introduced in two previous papers of the author [11], [12]. We assume that the energy of the quasi-stationary nucleon state is vacuum index dependent and it is defined by the following formula

$$E_{Nucleon}(n) = \frac{m_0 c^2}{n^2} - m_0 c^2 \qquad (3)$$

where m_0 is the rest mass of the nucleon bound to the nucleus and n is the hidden vacuum refraction's index of the accelerated nucleus.

We conceive the nuclear interaction to be caused by the nuclear electromagnetic fields of the accelerated nucleons, which we assume to be described by the following coupled equations

$$\left(\nabla^2 - \frac{n^2}{c^2}\frac{\partial^2}{\partial t^2}\right)\phi_n = \frac{E_{Nucleon}(n)}{\hbar^2}\phi_n \qquad (4)$$

$$n = 1 + \frac{\alpha \phi_n}{m_0 c^2} \qquad (5)$$

with ϕ_n the nuclear electromagnetic field solution of this generalized Klein-Gordon equation and α a phenomenological constant dependent on the atomic number Z of the nucleus, on the nuclear temperature and on the external pressure.

We suggest an approximate iterative method to solve this equation based on inserting on the right member of the equation (5) a phenomenological nuclear potential, for example a Coulomb one or a Yukawa one, obtaining a vacuum index at the first member of the equation that can be inserted in the first and second member of the equation (4), whose solution will give the first order approximation to the initial chosen potential.

We expect that approximate solutions of the nucleon potential could be developed as power series in α which could converge for some subfamily of initial conditions and potentials to the true solution.The quantum Schrodinger like nuclear wave function could be recovered by an ensemble average of the nuclear potential on the vacuum index hidden variable by the following formula

$$\psi_{Schrodinger}(n') = \int_1^{n'} \phi_n(n)\rho(n,t)dn \quad (6)$$

with n' the vacuum index after the decay process, $\psi_{Schrodinger}$ the solution of the Schrodinger equation with the chosen potential and $\rho(n,t)$ is an unknown probability distribution of the vacuum index.

We suggest to calculate the variation of the nucleus mass m_0 by the following formula

$$\Delta m_0(n') = -\frac{1}{c^2}\int_1^{n'} \frac{d}{dt} E_{Nucleon}(n)\,\rho(n,t)dn \quad (7)$$

which could be justified by assuming a dissipative nuclear force due to vacuum friction in analogy with recent studies on vacuum friction force [14].

We propose, exploiting an analogy with scattering processes, to describe the electromagnetic radiation emitted during the nuclear reaction by the following formula

$$\Delta E(n') = -\int_0^{V_k} \frac{\nabla[\varepsilon(n)\,{\phi_n}^2]}{8\pi} d^3x = \Delta E_{Nucleon}(n') \quad (8)$$

with $V_k$the volume of the final stable nuclear surface defined by

$$\nabla n(V_k, t) = 0, \quad (9)$$

with $$\varepsilon(n) = \frac{\varepsilon_0}{\sqrt{n}} \quad (10)$$

the dielectric constant of the excited polarized nucleus and the integral is the nuclear electromagnetic energy density analogous to the one introduced in recent studies on dynamic vacuum model [11], [13]. The previous equation could allow to deduce the unknown probability density $\rho(n,t)$ inserted in the formula (6) and (7) or on the contrary inserting a particular one, for example a Gaussian one, could be deduced the effective dielectric constant of the excited nucleus. We want to remark that this formula could be tested experimentally noting that the inverse of the first member of the previous eqution, multiplied by the Planck constant, is an estimate of the duration of the nuclear process (for example the nuclear fission time).

Secondly we note that the nucleon averaged velocity variation during the disintegration can be assumed to be proportional to the square root of the nucleon averaged energy variation in equation (8), by the following generalization of the classical equipartition Theorem

$$\Delta V_{Nucleon}(n') \propto \sqrt{\frac{2\Delta E(n')}{\Delta m_0(n')}} \quad (11)$$

The allowed and observable classical nuclear transitions or reactions will be those one with positive radicand in the previous formula.

We hope that approximated solutions of the proposed selfconsistent model will be useful for predicting nuclear fission time and more generally will pave the way to a better theoretical description of the recent experiments on nuclear assisted reactions [8], [9] and its possible implications for the prospective of exploiting and controlling in a deterministic and more effective way the nuclear energy .

III. CONCLUSIONS

We propose a self consistent local hidden variable model of nuclear reactions based on two selfconsistent coupled equations describing the dynamics of nuclear electromagnetic fields emitted by accelerated nucleons by a generalized Klein-Gordon equation with a variable light speed.

We assume that every stable nucleus can be described as an open quasisystationary system interacting with a dynamic space time dependent vacuum; we suggest that the vacuum index describes the averaged effect of the fast vacuum fluctuations associated to the electromagnetic radiation emitted by its accelerated nucleons.

We then introduce a dissipative nuclear force that we suggest could explain recent surprising nuclear decay processes as spontaneous and environment induced nuclear fission, which are currently under experimental investigations in many laboratories.

We apply this hidden non conservative force to deduce the averaged mass variation of a decaying nucleus and the consequent emitted electromagnetic radiation.

We expect that this deterministic framework could stimulate a renewed discussion on the dynamic origin of stationary quantum transition rates and quantum tunneling probabilities, since we think it is inadequate the use of relativistic spin and cross sections for accelerated nuclear targets. In particular we believe it is necessary to conceive the nucleon spin as non intrinsic, but as an emergent property of path memory dynamics of accelerated pulsating particles.

We outline that Schrodinger like nucleon dynamics and nucleon spin forces are not rigorously justified for accelerated systems with variable space time dependent mass.

We hope, finally, that our tentative model could be generalized in the future introducing the nuclear electromagnetic vector potential and nuclear density current in our Klein-Gordon like equation, since, we think, it will be possible to deduce dynamically the Born probabilistic interpretation of the quantum wave function..

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