Constraints on quantum information field and "human gain medium" making possible functioning of social laser

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Abstract. Starting with the quantum-like paradigm on application of quantum information and probability outside of physics we proceed to the social laser model describing Stimulated Amplification of Social Actions (SASA). The basic components of social laser are the quantum information field carrying information excitations and the human gain medium. The aim of this note is to analyze constraints on these components making possible SASA. The soical laser model can be used to explain the recent wave of color revolutions as well as such "unpredictable events" as Brexit and election of Donald Trump as the president of the United States of America. The presented quantum-like model is not only descriptive. We shall list explicitly conditions for creation of social laser.

1. Introduction
The recent quantum information revolution has tremendous consequences not only for development of novel physical technologies, but even social ones. We know well about successes in quantum physical technologies related to quantum computing, cryptography, teleportation, and recently quantum stimulator: from philosophizing (Einstein-Podolsky-Rosen paradox, 1933) to real quantum technological projects (the recent EU call for 1 billion Euro). We want to point out to similar success in development of novel social technologies based, in fact, on quantum informational principles. These technologies exhibited they power in a series of color revolutions and recently in Brexit and the election of Donald Trump as the USA president.

The main consequence of the quantum information revolution is that nowadays quantum systems are treated as *carriers and processors of information.* A photon or an electron are just carriers of quantum bits. The physical structure of a system seems to be irrelevant for theoretical modeling. (Of course, it has to be taken into account in the process of the real physical realization.) Nowadays quantum mechanics (QM) has a few purely information and probabilistic interpretations, see, e.g., [1]-[9] and also appendix.

However, the majority of physicists (even those advertising the information interpretations) still think that carriers and processors of quantum information should follow very special physical laws. Thus, for them, it is difficult (and for many totally impossible) to accept that quantum information and probability theories can be applied outside of quantum physics.

In a series of works , see, e.g., [10]-[12], the author demonstrated that, in fact, the essence of quantum information processing is in sensitivity of systems to changes of surrounding contexts, adaptivity to environment.

These studies led to formulation of the **Quantum-like Paradigm** (Khrennikov):

The mathematical formalism of quantum information and probability theories can be used to model behavior not only of genuine quantum systems, but all context-sensitive systems, e.g., humans.

Nowadays quantum information and quantum probability are widely used in psychology, economics, finances, social and political sciences, see, e.g., [10]-[22] In particular, quantum probability relaxes some constraints on statistical data imposed by classical probability theory. One of such constraints is *the law of total probability and in general Bayesian inference,* see also appendix.

The use of quantum probability, instead of classical probability, can resolve some paradoxes of classical theory of decision making, economics, and game theory; e.g., the Elsberg and Machina paradoxes. In general the mathematical formalism of QM is useful to model a variety of psychological effects, e.g., the order, disjunction, and conjunction effects, see, e.g., the monographs [11], [15].

Recently the author of this paper presented a novel application of quantum theory outside of physics, the model of a kind of social laser [17, 18], describing *Stimulated Amplification of Social Actions* (SASA). Here one has to use more advanced methods of quantum theory comparing with the previous works about decision making and cognition. In particular, QM cannot describe functioning of lasers. The formalism of quantum field theory (QFT) has to be explored. The detailed presentation of this model can be found in open access paper [18]. However, considerations in both papers [17], [18] are rather longly and not well structured. In this paper we present the formulation of explicit conditions which should be imposed onto the two basic components of the social laser, the quantum information field and the human gain medium. The components satisfying these conditions can serve for design of the SASA process. These conditions will be listed in the compact form comparable with the corresponding conditions on the components of the physical laser.

The aim of the creation of the quantum-like model of social laser is to explain the recent wave of color revolutions (at the post-Soviet territory, Middle East) as well as such "unpredictable events" (from the viewpoint of the modern democratic system) as *Brexit and the election of Donald Trump as the president of the United States of America,* see section 3. The presented quantum-like model is not only descriptive. We shall list explicitly the conditions implying the possibility of initiation of SASA.

2. Laser

Since we hope that this paper will be readable for researchers from the fields of psychology, sociology, management, political science, we start with the brief recollection of the history of laser. Invention of lasers was one of the main technological outputs of quantum physics. The theoretical basis for laser-invention was implicitly present in works of Einstein on stimulated absorption and emission (1917). In 1939, Soviet physicist Fabrikant considered the theoretical possibility of stimulated amplification of microwaves. But only in 50th, Townes in cooperation with Gordon and Zeiger designed and realized at the lab level the first microwave amplifier, nowadays such devices are known as masers. Townes's maser was incapable of continuous output. In 1955, Prokhorov and Basov suggested optical pumping of a multi-level system as a method for obtaining the population inversion, later a main method of laser pumping.

For completeness of presentation, we present the picture illustrating absorption of photons by atoms and spontaneous and stimulated emissions, see Fig. 1.
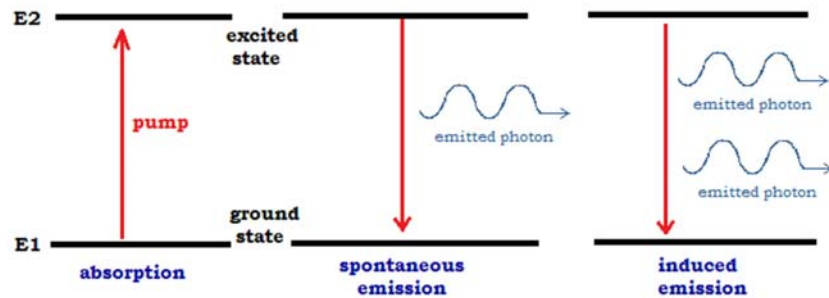
Figure 1. Absorption and spontaneous and stimulated emissions

For simplicity, we consider the two level atom. It has the ground and excited states with energies E_0 and E_1, respectively. The energy gap between these levels is given by $\Delta = E_1 - E_0$. Any atom in the ground state can absorb a photon with energy which is equal to this gap. An atom in the excited state can spontaneously emit a photon of energy Δ. If there is an ensemble of atoms, then spontaneously emitted photons are not coherent, i.e., they propagate in random directions and have random polarizations. Stimulated emission is a more interesting process. If an atom in the excited state interacts with a photon of energy Δ, then this atom emits a photon. Thus one photon produces two photons. The main feature of these two photons is that they are coherent, i.e., they have the identical states.

Now suppose that we were able to prepare an ensemble of atoms in the excited state. Suppose that one of them has emitted (e.g., spontaneously) a photon. Then interaction of it with some excited atom would lead to emission (stimulated by this photon) of new photon. These two photons by interacting with two atoms generate four photons. We have the cascade process of stimulated emission. The crucial difference of this process from spontaneous emission is that the output flow consists of coherent radiation, i.e., the states of emitted photons are identical.

To design laser one has to be able to create ensembles of atoms in which more than half of atoms are in the excited state - to approach the population inversion. This is the main problem and complexity of its solution explains why lasers were not created in 1920th. In fact, it is impossible to approach the population inversion for an ensemble of two level atoms; one has to operate with at least three level atoms (Prokhorov and Basov).

3. Recent "social revolutions": from post-Soviet states and Middle East to UK and USA

Color revolutions started at territory of the former Soviet Union, e.g., Georgia's Rose Revolution (2003), Ukraine's Orange Revolution (2004), Kyrgyzstan's Tulip Revolution (2005), Belarus' Jeans Revolution (2006), Moldova's Grape Revolution (2009), second Ukraine's Orange Revolution (2014). We can also mention Lebanon's Cedar Revolution (2005), Kuwait's Blue Revolution (2005), Myanmar's Saffron Revolution (2009). Recent years were characterized by the wave of color revolutions at the Middle East: Tunisia's Jasmine Revolution (2011), Egypt's Lotus Revolution (2011), Muslim military upraises in Iraq, Libya, Syria.

We emphasize that the diversity of opinions and theorizing about these social events presented in socio-political literature is really amazing, cf. [23]-[28]. There is no consistent and commonly acceptable theory of these phenomena. We shall explore the quantum-like laser model to describe the possibility of explanation of these events.

We point to the following strange features of all these color revolutions which are debated in political literature:

- No strong and bright leaders.
- No clear programs and aims.

Masses demonstrate coherent social actions (in the variety of forms, from massive protests and military upraises to referendums and elections) without leaders such as, e.g., Lenin and Trotsky or Atatürk. Such "revolutions" happen practically spontaneously and typically they are ended simply as relaxation of "energy of masses", i.e., without real constructive output.

4. Physical Laser: basic components and their features

Laser's operation is based on two components: *the quantum electromagnetic field and the gain medium* which is compound of atoms.

The quantum electromagnetic field interacts with matter with the aid of its excitations known as photons (carrying discrete portions of energy proportional to their frequencies). To simplify transition to the social modeling, we ignore polarization of photons. This field has the following features playing the fundamental role in functioning of laser:

- (F0) Addivity of physical energy carried by photons.
- (F1) Indistinguishability of excitations: two photons of the same energy cannot be distinguished.
- (F2) Bose-Einstein statistics of excitations: a few photons can occupy the same energy state.

Additivity of energy is so fundamental in physics that including of (F0) into the fundamental features of photons may seems strange. However, we are preparing the framework for the corresponding social considerations.

This is also a good place to make the following foundational remark. In contrast to a classical field, a quantum field cannot be imagined as a "physical field" propagating in space-time. This is the symbolic operational expression describing interactions of its excitations with matter (in the case of laser - with a gain medium). One may say that, in contrast to the classical electromagnetic field which can be imagined as continuously propagating in the space waves of energy, the quantum electromagnetic field seems to be nonphysical. However, physicists would not agree with such a viewpoint. Of course, believe in "reality" of the quantum electromagnetic field is often based on the rather naive picture of photons propagating in physical space. We stress that the latter is simply the relict of the classical thinking.

Laser's gain medium is composed of atoms (treated as quantum systems). Again, to simplify transition to the social modeling, we ignore electron's spin and degeneration of atom's levels. Atoms have the following features playing the fundamental role in functioning of laser:

- (G1) The discrete spectrum of energy.
- (G2) Fermi-Dirac statistics: only one electron in an atom can occupy the fixed energy state.
- (G3) An atom can absorb and emit only discrete portions of the energy, adapted to the differences between levels.
- (G4) Atoms in the gain medium have the same spectrum (the structure of energy levels).
- (G5) Stimulated emission.

5. Thermodynamics from combinatorics of state distribution

The combinatorial approach to thermodynamics, see, e.g., Schrödinger [29], provides the possibility to exclude physical components from reasoning leading to the basic thermodynamic laws. This approach is applicable to arbitrary systems (i.e., not only physical ones) which are characterized by the possibility to assign them states corresponding to the fixed values of some quantity E which is *additive with respect to elements of an ensemble of systems.* We can call it, e.g., *energy.*

In physics E is the "real" physical energy. In our considerations E will have the meaning of the *social energy.* Similarly to the physical energy, the social energy represents potentiality to perform social actions. A higher value of E can generate stronger action and its strength is proportional to E.

This is a good place to make another foundational remark. The classical treatment of the physical energy as the objective property of a physical system cannot be extended to quantum physics. We cannot consider "photon's energy" as its objective property. In quantum physics we can speak only about observables and observable quantities. Thus "photon's energy" is meaningful only as the result of measurement of energy which is performed, e.g., with the aid of photodectors. This quantum interpretation of energy (as well as other quantum quantities) is very important for justification of invention of its social analog. We do not claim that each individual "carries" some portion of social energy. The value of the social energy can be obtained through some measurement procedure. Of course, the specification and calibration of social measurement procedures is the separate and complex problem. But heuristically the social energy is not more mystical than the physical energy of a quantum system. This discussion is heavily based on treatment of humans as quantum-like systems, see introduction.

We proceed under the assumption about the possibility to assign the energy-like quantity E to systems under consideration (where "assign" is understood very generally - matching with quantum and quantum-like phenomenology). Then we obtain two different thermodynamical models:

- Thermodynamics of distinguishable systems.
- Thermodynamics of indistinguishable systems.

In physics, the first case corresponds to classical systems and the second one to quantum systems. In thermodynamics of indistinguishable systems, we distinguish two types of systems such that

- Any number of systems can occupy the same state (Bose-Einstein statistics).
- The fixed number, say q, of systems can occupy the same state (parastatistics).

Parastatistcis corresponding to $q = 1$ (the same state can be occupied by only one system) plays the most important role in quantum physics and it is known as Fermi-Dirac statistics. Only this kind of parastatistics can be found for real quantum systems. In social quantum-like modeling the question of possible types of parastatistics is open. However, to make life simpler, we proceed similarly to quantum physics.

6. Social Laser

6.1. Basic components and their features
The basic components of social laser, a structure performing stimulated amplification of social actions are

- Quantum information field, its excitations - quanta of information.
- Gain medium: humans.

The quantum information field was introduced in [17] and this paper contains the extended foundational discussion. This field provides the operational representation of information flows

produced by mass-media, TV, and Internet. Excitations of this field carry information about some events. They can be considered as quanta of such field. Information carried by these information quanta encodes portions of social energy.

We list the basic features of the quantum information field making possible creation of social laser:

- (IF0) Addivity of social energy: energy transmitted to a person by excitations of the information field is integrated.
- (IF2) Indistinguishability of information excitations: the content of messages is not analyzed, we simply absorb social energy carried by them.
- (IF3) Bose-Einstein statistics of excitations: messages with totally different content can carry the same portion of social energy

We now list the basic features of human gain media making possible creation of social laser:

- (IG1) The discrete spectrum of the social energy.
- (IG2) Distribution of the social energy in individual's state space follows Fermi-Dirac statistics.
- (IG3) An individual can absorb and emit only discrete portions of the social energy, adapted to the differences between his/her levels.
- (IG4) Individuals belonging to the gain medium have the same spectrum.[1]
- (IG5) Stimulated emission of the social energy.

In this model a person "falling" from the energy level $\mathbf{E}_{i+1}$ to the lower level $\mathbf{E}_i$ cannot stop in between. This matches well the discrete social layer structure of the modern society. There is no place for those who does not match to the discrete structure of social layers.

6.2. Human gain medium: comments

In our model human being is treated as an *information transmitter*. He can absorb social energy carried by the information field; he can carry a portion of energy, and he can emit a portion of energy.

To be able to create a population G of individuals which would function as a kind of laser emitting waves of social energy, the processes of absorption and emission of social energy have to be discrete. *Individuals in G have to have the discrete structure of their energy levels.*

Consider the simplest case of the two level structure of individual's social energy. She, say Alice, can occupy either the ground state characterized by the minimal energy level $\mathbf{E}_0$ or the excited state with energy $\mathbf{E}_1$. She can absorb or emit only portions of energy $\Delta = \mathbf{E}_1 - \mathbf{E}_0$.

6.3. Quantum information field: comments

In our model an information excitation is characterized completely by its social energy. Thus from a variety of features characterizing an event we extract only one - the magnitude of the social energy carried by this event. Other its features are ignored (in this simplest model). Thus two events O_1 and O_2 belonging to the same type of excitations, i.e., having the same social energy, are indistinguishable.

The model can be generalized to take into account the content of an event. Similarly in reality an excitation of the quantum electromagnetic field (a photon) is characterized not only by its energy (which is proportional to the frequency), but also by its internal degree of freedom

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[1] Of course, in reality it is impossible to prepare an ensemble of systems with precisely the same spectrum. In physics, variation of spectra follow the Gaussian law. One can expect this even in social systems.

- polarization. Thus social events can be assigned with some content characteristics, say politics, economics,....

In contrast to quantization in physics, the origin of social quantization is trivial. This is the ability of humans (and simpler cognitive systems) to represent reality as a chain of discrete events.

6.4. Indistinguishability of excitations of the quantum information field
Indistinguishability is the basic feature of information delivered to consumers by modern mass-media. In the modern society it is approached through creation of a massive flow of information such that, for people (receivers of information), it is difficult to inspect its content. They would "absorb information only to absorb information." Here the amount of the social energy carried by information communication is the subject of interest and not its content. People absorb information from TV, newspapers, Internet, mobiles. There is no neither time nor mental resources to analyze its content.

Such people overloaded by information differ crucially from people who leaved on the Earth say 30-50 years ago. We can speak about *post-human.* From the mental viewpoint, this is really a new being. Although biological differences are not (yet?) visible, behavioral differences are evident.

7. The probabilistic interpretations of quantum mechanics: the Växjö interpretation and Quantum Bayesianism

By the so-called Växjö interpretation of QM [2]-[5] QM is treated as a novel probabilistic formalism producing nonclassical probabilistic effects in the form of *violation of the formula of total probability.* The classical law of total probability is modified to take into account the interference term generated by incompatibility of observables. Quantum probabilities are interpreted as objective probabilities with emphasizing their frequency content.

Fuchs and Schack [6], [7] also proposed the probabilistic interpretation of QM known as Quantum Bayesianism (QBism). And they also pointed to violation of the classical law of total probability. Their modification of this law differs from the Växjö version and it is based on the use of so-called symmetric informationally complete positive operator valued measures (SIC POVMs). Fuchs and Schack interpret quantum probabilities as subjective probabilities and they stress the private agent perspective in observers analysis of experimental data.

I should honestly recognize that the subjective probability approach matches better applications of quantum probability to model cognition and the process of decision making. Thus QBism can be considered as the basic interpretation of the quantum-like approach to decision making [30]. However, the QBists' modification of the classical formula of total probability [6], [7] is hardly applicable for such purpose. Here we simply do not have SIC POVMs. Observables do not provide complete information about the belief state of a decision maker. Therefore the Växjö version of this formula [2]-[5] has to be in the use. It is based on the pair of incompatible observables (neither of them should be informationally complete).

However, in the social laser model we have to proceed with objective probabilities determining the population levels for the ground and excited states of individuals in human gain media. Thus in such modeling we have to use the Växjö interpretation of QM.

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