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Induction of Forces at Distance Performed by Semiconductor Laser Diodes

Elio B. Porcelli[1]and Victo S. Filho[1]
[1]H4D Scientific Research Laboratory, São Paulo,São Paulo State, 04674-225, Brazil

ABSTRACT:*In this work, we report the generation of external forces induced by the operation of semiconductor laser diodes. We experimentally detected small anomalous nonlocal forces raised by the devices in operation. The effect due to the diodes cannot be associated with the known interactions as the electromagnetic one and can also not be explained by traditional theories. Hence we here propose that our theoretical framework early reported in literature, in which anomalous effects in other physical systems could consistently be explained by a preexisting state of generalized quantum entanglement between the external environment and the devices in operation, can indeed explain the effect produced by the laser diode as well. The values of the macroscopic observables calculated in such a theoretical framework for our case involving semiconductor laser diodes revealed reasonable agreement with the experimental measurements performed, so that the non-locality hypothesis based on the generalized quantum correlation between devices and environment is shown as a consistent explanation for the anomalous effects observed.*

Keywords*: Laser diode, Induction of Force, Quantum Entanglement*

I. INTRODUCTION

In last decades, an intense technological development concerning to the fabrication of semiconductor laser diodes have been performed and a lot of different devices with different materials and wavelengths have been invented [1-6]. For instance, some cases comprise a nitride semiconductor laser by which it is produced a stable high power room-temperature continuous-wave oscillation in fundamental mode [4], a compound diode with excellent temperature characteristics [2] or involving semiconductor laser diodes which can emit light in the visible short wavelength spectrum of light, particularly in the blue to violet and also in the ultraviolet region [1]. In other relevant work [7], it was demonstrated the first laser diode fabricated from wide-band-gap II-VI semiconductors, capable of emitting coherent light at a wavelength of 490 nm from a ZnSe-based single-quantum-well structure under pulsed current injection at 77 K, the shortest wavelength ever generated by a semiconductor laser diode.

As known, a laser diode is a device with a wide and intrinsic semiconductor region not doped between a p-type semiconductor and an n-type semiconductor region (PIN diode). The carriers (electrons and holes) are pumped into that region from the n and p regions, respectively. The modern lasers use the double-hetero-structure implementation, in which the carriers and the photons are confined in order to maximize their chances for generation of light. The objective of such lasers mainly comprise the generation of the coherent beam with more and more better properties as the recombination of all carriers to produce light. Thus, laser diodes are fabricated using direct band gap semiconductors. The active layer in those devices most often consists of quantum wells, which provide lower threshold current and higher efficiency [8].

From those features early cited, there are some interesting and useful applications [5, 6, 9-11], as the case of a laser Doppler velocimeter, using the self-mixing effect of a semiconductor laser diode [5] or the case in which the device was suited for uses where high power output and long life-time are required, such as excitation light source for optical fiber amplifiers [6].

It is relevant to say that the laser beam light is the main feature to be provided by semiconductor laser diodes, aiming to improve the characteristics for applications [4, 6]. The highly ordered direct current of charge carriers injected into the active region of these electronic components above the lasing threshold can be used in innovative ways [5]. A novel possibility of application can be associated with a new theoretical concept [12] in which all particles which are part of macroscopic objects are widely coupled to each other via quantum entanglements: it can induce forces at distance and self-induction of forces. Considering that, a force can be induced in external objects, thrusting them, and a force can be inducted in the own semiconductor laser diode structure for itself propulsion.

In this work, we report a method for using semiconductor laser diodes as an inductor of force in other external objects and on itself comprising generalized quantum coupling between a highly concentrated direct current of ordered charge carriers of a semiconductor laser diode beam and external particles or objects placed in the neighborhood of the beam environment. The method here proposed also comprises inductors of force which are not performed directly by the beams of semiconductor laser diodes; the extension whereby semiconductor laser diodes can be used in arrays and the technique wherein the semiconductor laser diodes are electrically pumped. The method also can comprise diodes, as reported above, wherein the semiconductor laser diode is a single structure, a hetero-double structure or a quantum well [13].

In next section, we describe the experimental work performed in order to detect the forces induced by the diode, beside the characteristics and the field of this invention. In the following, we briefly describe the theoretical framework that can describe the phenomenon and discuss the comparison between the experimental measurements for the cases of one unique laser and a set of two parallel lasers and the corresponding theoretical results. In the last section, we discuss our main conclusions.

II. EXPERIMENTAL WORK

A. Experimental Assembly

In this section, our objective is to report the features, the experimental tests involved and the field of the invention previously discussed in last section. The present invented device relates to a semiconductor laser diode used for induction of a field of forces in external objects and for self-induction forces in its own structure. Specifically, we assert that the induction generation is performed due to its internal electrical direct current widely coupled with the environment. This coupling is not intermediated by the light laser beam and it results from quantum entanglements. The direction of the induced forces is the same as the charge carriers moving inside the active region.

In table I, we show the data concerning to the instruments that we have used in the experimental procedure. In order to measure the anomalous forces raised by the laser diodes, we have used high advanced instruments described in more technical details in table I, adopting the same experimental technique in earlier works. The features of the semiconductor laser diodes used in the experiment are also shown in table I.

TABLE I. Data concerning the instruments and laser devices used in our experimental work, in order to measure the magnitude of anomalous forces raised by the laser diodes in operation.

Device	Features
USB Accelerometer	Gulf Coast Data Concepts Model X6-2; Educational Purposes Stand-Alone Operations; 3 Axis Accelerometer; 2g or $\pm$6g range in each axis; Sample rates of 20, 40, 80, 160 and 320 Hz
Digital Ampere Meter	UNI-T Model UT30B; Current Range 200 μA $\sim$ 10A Resolution 100 nA (for 200 μA DC Current) $3\frac{1}{2}$ Digits LCD Display
Laser Diodes	Nominal current: 0.35 A; TO-56 laser diode encapsulation Wave length: 532nm (green color); TO-56 laser diode encapsulation Light output power W: 200 mW
Potentiometer	Resistance: 200 Ohm; Power: 200 W; Weight: 39 g

The invented device built in order to verify the effect has been characterized in our experimental tests and has been submitted to patent analysis [14]. From now on we describe in more detail the device and the experiments realized by means of the figures shown in the following.

In Fig. 1 we diagrammatically show a geometrical projection of the force induction that emerges from the resonant cavity 1.5 in the parallel direction of the direct current flow (upwards direction). As shown, the label 1.5 indicates the resonant cavity consisting of an optically transparent crystal. Label 1.6 indicates the back face of the resonant cavity 1.5 and the label 1.7 indicates the front face of the resonant cavity 1.5. The label 1.1 indicates the laser beam direction emerging from the front face 1.7 and back face 1.6 of semi-reflective resonant cavity 1.5. Label 1.2 indicates the current flow in the upwards direction through the resonant cavity 1.5 and label 1.3 indicates the projection of the induction of force designated. Labels 1.4, 1.4a and 1.4b are the semiconductor layers. In Fig. 2 we show in a diagram the divergence in the projection of the induction of forces according to the geometrical divergence factor d in the Y axis.

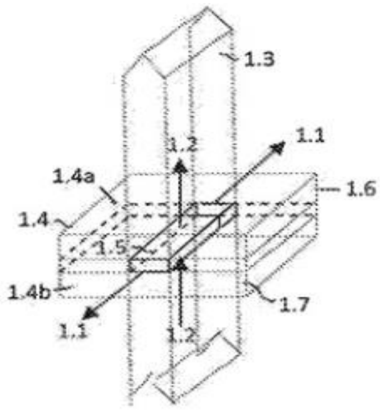

FIG. 1. Diagram of a geometrical projection of the force induction that emerges from the resonant cavity in the upwards and parallel direction of the direct current flow.

In the figure, we observe the following labels with their meanings: (i) label 2.1 indicates the resonant cavity where the force induction is projected from its upper area and lower area; (ii) label 2.2 indicates the projection of force induction with null divergence designated with dotted line; (iii) label 2.3 indicates the projection of force induction with some divergence designated with dashed line; and (iv) label 2.4 indicates the angle between the projection of induction of force with divergence and without divergence. The geometrical divergence factor d is the cosine of this mentioned angle. The intensity of the force induction in the upper region of the resonant cavity 2.1 will be inversely proportional to the cosine of that mentioned angle. Therefore, this intensity decays along the Z axis (distance from the resonant cavity upper face). Although in present days semiconductor laser diodes are often used for highly coherent and focused light beam generators with many different applications, we here show that important new applications can be performed, even without using their main functionality as the generation of laser beams. The special use of those electronic components for those new applications is their highly ordered direct electrical current concentrated in the active region above the lasing threshold operation.

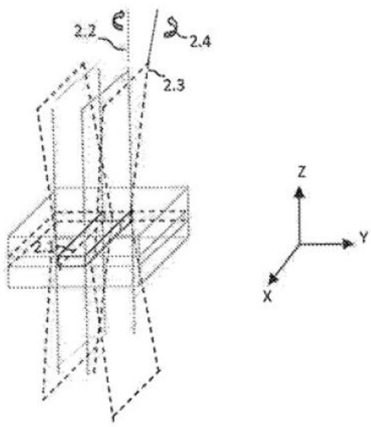

FIG. 2. Diagram of the divergence in the projection of the induction of force according to the geometrical divergence factor d in the Y axis.

The concentration of charge carriers in the direct electrical current is associated with the gain during the stimulated emission of photons and it is possible due to the coupling between the synchronized transition of the quantum state of the charge carriers and the highly organized photons confined in the light resonant cavity.
The main agents for such new applications are the coupled charge carriers (electrons) with the external particles in the environment (some of them are part of the macroscopic objects). The coupling between the highly

organized charge carriers (occupying a quite reduced number of different quantum states) and all other external particles is performed according to the concept of Generalized Quantum Entanglement (GQE). An amount of momentum is transferred from the charge carriers and the external particles in the case of a semiconductor laser diode. The phenomenon is very similar to those analyzed in early works involving anomalous effects, in which the momentum exchange is performed by different momentum carriers, as electric dipoles [15-17], magnetic dipoles [12], charge carriers in piezoelectric [18] or electrons in superconductors [19]. In case of a trivial conductor (a metallic wire), the charge carriers inside follow the flow along the same direction but they are not well concentrated and organized (occupying a quite large number of different quantum states). As such, the intensity of the induction of forces is extremely weak in comparison with semiconductor laser diodes even considering the same wide coupling via quantum entanglements. This particular attribute of a semiconductor diode laser allows a considerable induction of force in other external objects or in its own structure.

The most relevant attribute or feature of the effect is that external objects can suffer the influence of the semiconductor diode lasers independent of their material constitution. In fact, the induction of forces can affect all kind of objects or particles and this has not be realized by a laser beam because electromagnetic interactions can only affect electrical charged particles. This induction is related to the wide coupling between the particles, as predicted by the Generalized Quantum Entanglement framework. The intensity of induction depends directly on the intensity of the current flowing inside the semiconductor laser diode, specifically in the active region. Because of this, even components with low power (non professional applications) can generate some detectable force. Other dependence has relation with the gain of the active region. This parameter depends on the resonant cavity geometry and the density of charge carriers injected in the semiconductor (doped region).

The divergence of the induction of force is determined by such parameters (the resonant cavity geometry and the charge density in the semiconductor regions). Then, considering this, the induction may affect external objects placed at very high distance from the position of the semiconductor laser diode. In other words, the space geometry of the induction can be focused or not, but this can be adjusted accordingly.

The main mentioned parameters, such as intensity of internal current, geometry of resonant cavity and density of charge carriers in the semiconductor material, can determine the induction of forces on its own structure as well. Auto induction can cause motion or even reduce the apparent weight of the device.

The curve of behavior of the induction of forces F as a function of the intensity of the direct current flow can be analyzed in Fig. 3. Above the threshold lasing current (I_{th}), the intensity of the induction of forces linearly increases as function of the direct current increasing. This behavior is the same as the optical power because of the optical coupling with the charge carriers (the real origin of the induction of force).

The diagram in Fig. 4 comprises two figures (Figs. 4a and 4b), in which it is showing the diagram of projection of the induction of forces. Such a projection is shown in external objects in Fig. 4a and the possible thrusting in the laser diode structure caused by the self-induction of force in Fig. 4b.

Figure 3

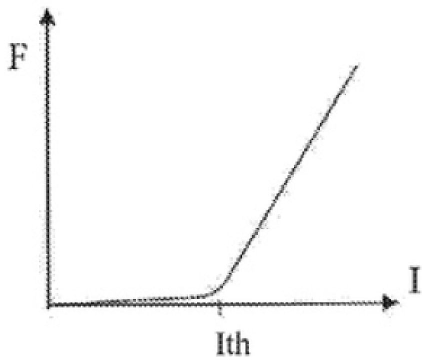

FIG. 3. Plot of the behavior of the induction of forces as a function of the intensity of the direct current flow.

The encapsulation of the semiconductor laser diode shown in Fig. 4a and Fig. 4b is a TO-56 type.

Both frames in Fig. 4 consider the usual encapsulation of a popular semiconductor laser diode in the market. In the figure, label 4a1 indicates the encapsulation of the popular laser diode. Label 4a2 indicates the projection of the force induction with the length of the resonant cavity (considering a null divergence) emerging from its back and front faces. Label 4a3 indicates the force induction direction. Label 4a4 indicates a neutral body illuminated by the induction of force projection and label 4a5 corresponds to a semiconductor diode laser structure in the diode encapsulation in which is placed the resonant cavity and its induction of force projection emerging. Label 4b1 indicates a semiconductor laser diode encapsulation thrust (see label 4b3) in the opposite direction than the projection of the force direction - that is, the same direction than the direct current injection of electrons in the active region (see label 4b2). This is a propulsion system using the interaction of those electrons and the environment via GQE and the action-reaction principle.

An Electrically Pumped Semiconductor Laser Diode has its active medium formed by a p-n junction of a semiconductor diode similar to that found in a light-emitting diode (LED). This is formed by doping a thin layer on the surface of a crystal wafer to produce an n-type region and a p-type region, one above the other, resulting in a p-n junction between both regions. The mentioned regions have two kinds of charge carriers named holes and electrons, respectively injected in the crystal for p-type and n-type.

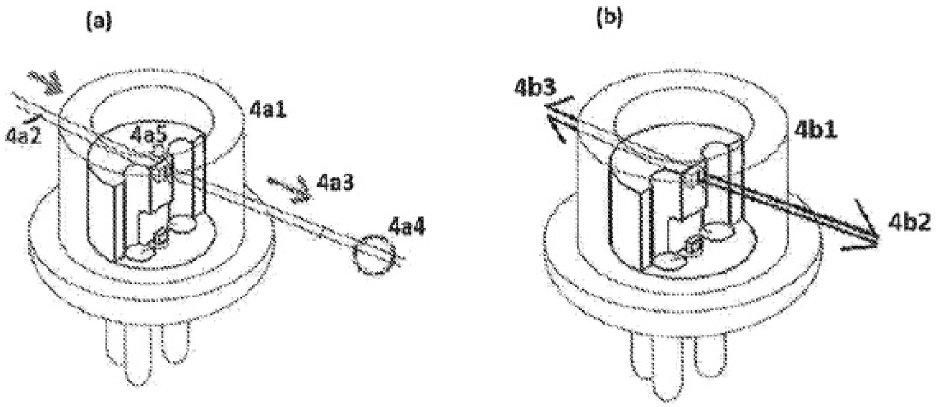

FIG. 4. Diagram of the device in which is shown the projection of the induction of forces in external objects (frame 4a) and the possible thrusting in the laser diode structure caused by the self induction of forces (frame 4b).

A depletion region, devoid of any charge carriers, forms as a result of the difference in the electrical potential between n- and p-type semiconductors wherever they are in physical contact. A spontaneous emission of a photon happens when an electron and a hole are present in the same region where they recombine or "annihilate" and its energy is equal to the difference between the electron and hole energy states involved. Spontaneous emission gives the laser diode lasing threshold properties similar to a LED and this process is necessary to initiate laser oscillation.

Electrons and holes may coexist in proximity to one another, without recombining, for a certain time, in the absence of stimulated emission. Then a nearby photon with energy equal to the recombination energy can cause recombination by stimulated emission and this generates another photon of the same polarization, traveling in the same direction, with the same frequency and phase as the first photon. So this means that stimulated emission causes gain in an optical wave (of the correct wavelength) in the injection region, and the gain increases as the number of electrons and holes injected across the junction increases.

Beside the increase of electrons and holes injected into the junction (increase of direct current density in the active region), they obey a synchronized transition state energy. That effect means that the direct current in the laser diode (especially across the active region), is much more ordered than within a trivial conductor.

B. Experimental Results

In the following, we describe the measurements of induction of forces at distance by using the experimental setup described in last section.

All the valid measurements that we performed were in relation to X axis because it presented the smallest values of standard deviations (around 4.5 to 5 counts for a induced mark of nearly 1.5 count).

The technique adopted in order to obtain the measurements is similar to the procedure explained in Refs. [15, 16]. In the first step of the procedure, it was turned on the accelerometer. Then, we made measurements in off-period of 30 seconds followed by an on-period of 10 seconds (corresponding to the laser diode activation). Hence, in the following step one proceeded with an on-period of 10 seconds. The samples "off" were comprised between 22th and 26th seconds and the samples "on" between 33th and 37th seconds in order to guarantee that there was not any type of remaining mechanical perturbation due to the activation of both the accelerometer and the diode laser.

The induced force was calculated by means of the difference of averages of accelerations measured between the off-period and on-period. The accelerometer collected 1600 samples in each period in its maximum resolution when regulated to obtain 320 samples per second. The X axis of the accelerometer was fixed in order to remain in the horizontal plane, aligned in the upwards direction with the junction p-n of the laser diode.

In the experiments, it was used the accelerometer whose technical data are given in table I. Such a device is insensible to electromagnetic influences due to piezoelectric properties. In order to obtain a high accuracy, the measurements were proceeded with careful decreasing of acoustic noises in the environment, because one noted that they represented a relevant factor affecting the procedure.

In a first experiment, the average of the measurements of forces induced by a unique laser diode at distance was obtained by placing the accelerometer at 2cm from the resonant cavity of the laser diode. The values of the acceleration were measured and, as indicated in table II, were averaged in order to obtain our result indicated in the table. We measured them by using the advanced accelerometer configurated to scale them by the factor 16384 and obtained them in counts.

TABLE II. Measurement of the average values of forces induced by one and two laser diodes at the distance of 2cm between the resonant cavity and the accelerometer body. In the case of two lasers, the distance refers to the laser more to the left, so that the second laser is placed parallel to the first one and 1cm distant of it. The accelerometer is set so that 1 count = 9.78 / 16384 m/s^2.

Number of devices	Distance	Average Force (count)
1	2 cm	0.56875
2	2 cm	1.09

In the technical specifications of the instrument, one reads 1 count = (9.78 / 16384) m/s^2. As one can see in table II, the average of experimental measurements of induction forces by one unique laser diode at a separation distance of 2cm corresponds to 0.56875 counts. In table III, one can realize that the corresponding theoretical value is 0.4662 count, a value 18% smaller.

TABLE III. Comparison of the measured values of forces induced by one and two laser diodes separated by 2cm of the accelerometer and the corresponding theoretical values.

Experimental (count)	Theoretical (count)	Percentage Error
0.9324	1.09	14 %
0.56875	0.4662	18 %

In a second experiment, the average induced force raised by two laser diodes at a distance of 2cm of the accelerometer was measured. As one can see in the second line in table II, the measurements were obtained at the same earlier position of the accelerometer in the case with an unique laser. The experimental value of average induced force was 1.09 count. In the table III, we can see that the theoretical value is 14% smaller, that is, we obtained in our calculations 0.9324. We also implemented measurements without activation of the laser diodes and the absolute values measured were very different (-0.197 count), indicating that the induction of force was notable in despite of their weak magnitudes.

In next section, we summarize the main points of GQE and its application to the present experimental work, by describing the procedure to obtain the theoretical values shown in table III.

III. THEORETICAL DESCRIPTION

A. Generalized Quantum Entanglement

Our method of calculation considers, for the microscopic constituents of a physical system, the property of preexisting state of generalized quantum entanglement, so that its existence in extreme conditions would be manifested and its effects could occur and be observed. Rather we assert that the effects can be calculated, in order to predict the values of macroscopic observables associated to the systems. As known from literature [20-23], the quantum entanglement is the consequence of an interaction between two [20-22] or more particles in an arbitrary past time, so that subsequently each particle in the combined state keeps the information from each other, even for large distances, a feature of nonlocal phenomena [23].

The issue concerning to effects of generalized quantum entanglements in systems of huge number of particles is an important point to be analyzed if we desire to understand and even quantify the influence of their effects on our macroscopic world [24]. Despite the issue of the absence of the phenomenon in our daily world and that physicists always assume that these supposed entanglements with the outside world can be ignored because the effects of entanglements would somehow cancel each other so that they would not need to be considered in practice, in any actual situation, others argues that one mystery or puzzle of entanglement consists in its tendency to spread. It would seem that eventually every particle in the universe should become entangled with every other or even they would already be all entangled with each other. This point is reinforced in a recent work [25]. In fact, entanglement is a ubiquitous phenomenon and the huge majority of quantum states are actually entangled, so it becomes very hard to understand why we barely notice its effects in our direct experience of the world. We also agree that such a restricted vision is right in many systems, but it is merely partial and in some cases it hides the general behavior or effects in a system with many bodies.

So, we hypothetically suppose the arbitrary idea that all microscopic constituents of physical systems are quantum entangled, as is the case already reported in literature [25]. Despite the effects of this property cannot be easily demonstrated or even measured in case of trivial physical systems, we assert that in specific conditions such global effects can be detected. In the case of magnetic cores, it is needed the application of strong magnetic fields in order to realize the presence of the generalized quantum entanglement among the dipoles of the dielectric and the external environment. In the case of capacitors, it is needed the application of high voltage in order to realize the presence and or the effects of the generalized quantum entanglement among the dipoles of the dielectric and the external environment. The conjectures of preexisting quantum entanglement and its influence on the macroscopic observables of the system can be checked in a lot of physical systems, as the system constituted by the laser diode, analyzed in this paper as a possible case of application.

Other important issue is the calculation of observables in the systems involving many particles. Although there is a high complexity in the calculations in systems of many entangled particles, some macroscopic observables can offer a real possibility of successfully calculating their physical values in an easier way, with a relatively good accuracy, as we can check in the formalism reported in Ref. [12].

In order to understand the model, without loss of generality we show the idea in a simple way by considering two entangled particles with not null dipole moment. The dipole moments can be oriented along ($|0\rangle$) or against ($|1\rangle$) the external fields. In this condition, the following two entangled states for the pair of dipoles can be obtained:

$$|\Psi_2\rangle = \frac{|01\rangle - |10\rangle}{\sqrt{2}} \quad (1)$$

and

$$|\Psi_3\rangle = \frac{|01\rangle + |10\rangle}{\sqrt{2}}. \quad (2)$$

It means that some change in the local external field (e.g. intensity) applied in a dipole of the pair can change the dipole moment of another one. The total dipolar moment of the system must be conserved in any condition and the variation of dipole moments causes an exchange of a real force between them, but this kind of interaction cannot be taken in place by local forces in cases in which there is a negligible magnetic coupling. The intensity of the nonlocal force exchanged from a dipole to another one is directly proportional to its transition energy E:

$$E = -\vec{\mu} \cdot \vec{B}, \quad (3)$$

in which $\vec{\mu}$ is the magnetic dipole moment and $\vec{B}$ is the local external magnetic field where the magnetic dipole is localized.

This argument can be generalized accordingly for a system of N particles, even with N(N>> 1) magnetic dipoles coupled via quantum entanglement between the momentum and the environment. In fact, more and more academic works [26, 27] have considered studies concerning to quantum entanglement for many bodies or quantum information in macroscopic scale. In particular, there are works [28] consolidating the argument that the quantum entanglement is crucial for explaining a lot of macroscopic properties in high temperatures [28, 29].

In summary, it is worth to emphasize that all of those articles corroborate the hypothesis of manifestations of quantum entanglement for many particles in the macroscopic level [26-29]. It is also important to stress that such a feature allows us to use the classical formulation in our calculations.

Further there are nowadays some important works [30-36] reporting the existence of a macroscopic observable that reveals quantum entanglement between individual spins in a solid, a phenomenon called entanglement witness. In Ref. [30], the entanglement witness is shown as being more general (in the sense that it is not only valid for special materials), associating some macroscopic observables such as magnetic susceptibilityχ_m with spin entanglement between individual constituents of a solid. It was proposed a macroscopic quantum complementary relation basically between magnetization *M*, representing local properties, and magnetic susceptibility χ_m, representing nonlocal properties. By defining for the system of N spins of an arbitrary spin length s in a lattice the quantities:

$$Q_{nl} = 1 - \frac{kT\bar{\chi}}{Ns} \tag{4}$$

and

$$Q_l = \frac{\langle \vec{M} \rangle^2}{N^2 s^2}, \tag{5}$$

in which $\vec{M}$ is the magnetization vector, *k* is the Boltzmann constant, *T* the temperature and the susceptibility $\bar{\chi}$is defined as $\bar{\chi} \equiv \chi_x + \chi_y + \chi_z$, then it was shown in Ref. [30] that one has:

$$Q_{nl} + Q_l \leq 1. \tag{6}$$

Such quantities have specific meanings, that is, Q_{nl} represents the quantum correlations between the spins in the solid (nonlocal properties) and Q_l represents the local properties of individual spins.

The hypothesis of preexisting state of quantum entanglement indicates that there are no isolated systems, thus the magnetic core and the environment around it are both part of the same system where the inequality (6) can be considered accordingly. In other words,if one quantity increases then the corresponding counterpart quantity has to decrease. If Q_l increases and Q_{nl} decreases in the magnetic core, Q_{nl} decreases and Q_l increases in the environment and vice-versa. This is the same framework described before involving a simple system with two entangled magnetic dipoles. If we increase the intensity of a magnetic field (Q_l) applied in one then the nonlocal effects (Q_{nl}) must increase in the other.

B.Applicationt the Laser Diode Case

From the exposed in last section, we conclude that it is needed to find the classical observables that can empirically describe the phenomenon in the case of the semiconductor laser diode. According to this theoretical model named "Generalized Quantum Entanglement", all particles are widely coupled. Considering that point, the electrons of the highly ordered direct current are self-coupled and coupled with all external particles. These electrons have a holistic behavior considering that they obey the same quantum wave and because of this, they have a collective momentum. In this condition, the intensity of the collective momentum exchanged between the direct current and all external particles from environment can be increased and the increase depends on the intensity of the current. For instance, there is a momentum exchange between a current flow in a trivial conductor and the environment around it, but its intensity is weak in comparison to a direct current in the active region in a semiconductor laser diode.

A parameter that determines the intensity of the momentum exchanged between them is the gain factor of the semiconductor laser diode. This parameter depends specifically on the resonant cavity geometry (dimensions) and the density of charge carriers injected for semiconductor regions n and p. The space divergence of the induction depends on the geometry of the resonant cavity. Its direction of the resonant cavity is perpendicular to the laser beam projected from the resonant cavity and its direction is also parallel to the direction of the charge carriers movement (electrical current), as depicted in Fig. 1. According to this mentioned divergence, the intensity of the induction can be reduced or not depending on the distance from the resonant cavity. There is always a divergence in the laser beam and this must be adjusted accordingly by some optical resources like a lens considering the light propagation but, in case of the induction, its divergence is at a minimum for comparison and it depends on the dimensionality and geometric symmetry of the resonant cavity.

The direction of the force inducted in external objects depends on the direction of the direct current flowing in the active region, such as indicated in Fig. 1. In the same way, the direction of the semiconductor laser diode structure thrust depends on the antiparallel direction of the direct current flowing.
In terms of semiconductor laser diodes specifications, single mode (thin waveguide of resonant cavity in the vertical direction) and multimode (wide waveguide of resonant cavity in the vertical direction) types respectively generate a narrow light beam with a single wavelength and a wide light beam with multi wavelengths.

It means that the electrons from the direct current flowing by the active region in the single mode diode have the same energy state level and some spread energy level in case of a multimode diode. Because of this, the single mode diode is more useful for induction of force considering that the same energy state level means more collective organization.

In the case of single mode diodes, the induction of force can be proportional to some parameters such as the magnetic constant $\mu_0 = 4\pi \times 10^{-7}$ H/m, the resonant cavity gain G, the direct current I and the divergence factor of the induction d, considering the current values above the lasing threshold and usual temperature specification for the semiconductor laser diode. For this calculation, it is considered that the area of the induction of force is smaller than the area of the target object or at least it has the same size. If the area of the target object is smaller than the area of the induction of force then the intensity of the force will obey the rate

$$F'' = \frac{A_i}{A_t \times F}, \tag{7}$$

in which F is the force projected from the diode, F'' is the real force inducted in the target object, A_i is the induction of force geometric area and A_t is the area of the target object (partially illuminated).

The divergence factor of the induction is the cosine of the divergence angle with the direction of the force induction such as indicated by Fig. 2. In case of the force self-induced that generates a thrust in the semiconductor laser structure, the divergence factor value considered for the calculation is equal to 1.The curve of the force follows directly the curve of the laser beam emission intensity.Above the lasing current threshold such as indicated in Fig. 3, the induction of force increases abruptly. The induction can affect all kinds of different materials considering the wide coupling according to GQE concept and this attribute is different than a light laser beam, that it is an electromagnetic interaction affecting only charged particles.

The laser pointer has an internal semiconductor laser diode with an encapsulation of theTO-56 type and its position must be adjusted in order to ensure that the direct current above the lasing threshold is pointing downwards accordingly.
In the theoretical calculations of the macroscopic description of the process, it was needed to characterize the laser diode in order to determine the gain factor G by means of several measurements watching the output optical intensity versus the feeding direct current.

The intensity of the self-induction of forces F generated by this kind of semiconductor laser diode can be calculated using the formula

$$F = \mu_0 G I^2, \tag{8}$$

in which I is the nominal direct current in the laser diode, μ_0 is the magnetic constant of the vacuum and G is the gain factor of the laser. In our experiment, our calculations were made by considering as parameter values a 200 mA direct current I, a 400 resonant cavity gain G and the usual magnetic constant μ_0. Considering such values, an upward self-induction of force F equal to 2×10^{-5} N is generated against the weight force of the device on the sea level resulting in 2 mg weight reduction. It means that the load can be slightly reduced in this device. This self- induction of force F can be measured even considering its weak intensity.

The gain factor G is dimensionless and it is proportional to the square of the ratio of the stimulated responsiveness η of the stimulated emission phase (above the threshold current) with the spontaneous responsiveness η of the spontaneous emission phase (under the threshold current), that is:

$$G = \left(\frac{\eta_{stimulated}}{\eta_{spontaneous}} \right)^2 . \tag{9}$$

So, we obtained for our parameter G in the experiment:

$$G = \left(\frac{200 \text{ mW}}{350 \text{ mA}} \right)^2 \left(\frac{7.84 \text{ mW}}{114 \text{ mA}} \right)^{-2} ,$$

so that:

$$G = (0.571/0.068)^2 = (8.397)^2 = 70.51.$$

Such a gain factor elapses from the multiplication of quantity of charge carriers in the active region of the laser diode (resonant cavity) due to the process of stimulated emission.

The values of both responsiveness were obtained by means of trials of the laser diode by varying the direct current that was applied and measuring the light magnitude in the output (output power).

There is no multiplication factor of charge carriers in simple conductors, so that in the calculations it is not applicable the gain G in the formulas. Hence, that is the reason of induction forces generated start to be significant only for very high values of the electric current magnitude.

When one considers the formula (8) earlier described, the magnitude of the induced force that is calculated reads 10.85μN for a nominal direct current of 350 mA. Further the value of the acceleration measured by the piezoelectric accelerometer of 39g is 0.0027831m/s^2, that is, 0.4662 count (basic unit of the accelerometer).

Addictive effect of the induced forces was verified and, in the activation of the two parallel laser diodes and oriented in the same direction, we have the double of the force, that is, 0.9324 count or 21.70μN to the 39g accelerometer mass. In the experiment, one considered two laser diodes with same characteristics and presenting a nominal direct current of 350 mA.

Our tests with the induced forces indicated that there was not apparent reduction ofits intensity for different distances, by considering usual distances between the coverage of the accelerometer and the coverage of the laser diode (pointer) of 2cm. The tests were not made in a total controlled environment free of acoustic noises, seismic disturbances or thermal perturbations. However, we implemented some efforts in order to reduce such perturbations and detect their influences after several measurements in different conditions.

It is relevant to report that an internal "tilt" in the X sensor implying negative measurements of one gravitational acceleration component provided attractive or repulsive induced forces on that axis and increased their magnitudes when the accelerometer was touching the horizontal plane of the work bench in the experimental measurements realized.

C.More Complex Arrays and Structures in the Experiments and Applications

Regarding the type of semiconductor laser diodes useful for the present invention, components with a simple structure are extremely inefficient. Double hetero-structure lasers are much more efficient and more commonly used in the market. The advantage of a double hetero-structure laser is that the region where free electrons and holes exist simultaneously, which is known as the active region, is confined to the thin middle layer. This means that many more of the electron-hole pairs can contribute to amplification - not so many are left out in the poorly amplifying periphery. In addition, light is reflected from the hetero junction; hence, the light is confined to the region where the amplification takes place. The larger amount of electrons concentrated means the greater amount of momentum transferred to the outside. This is because these devices usually use an active region with a layer of a different thin material sandwiched by n-type and p-type semiconductor layer. If the middle layer is made thin enough, it acts as a quantum well. This means that the vertical variation of the electron's wave function, and thus a component of its energy is quantized.
Considering this, the efficiency of a quantum well laser is greater than that of a bulk laser because the density of states function of electrons in the quantum well system has an abrupt edge that concentrates electrons in the

same energy states that contribute to laser action and consequently with amplification of the moment transferred to the outside via quantum coupling, as mentioned before.

Multiple quantum well lasers are known as containing more than one quantum well layer and this feature can improve the overlap of the gain region with the optical waveguide mode. In order to compensate for the problem with a simple quantum well diode described above, that is, the thin layer is too small to effectively confine the light - another two layers are usually added on, outside the first three. These layers have a lower refractive index than the center of layers, and hence confine the light effectively. Such a design is called a separate confinement hetero-structure (SCH) laser diode and almost all commercial semiconductor laser diodes since the 1990s have been using this concept and therefore these popular components with less than 1 Watt optical power in the market can be used for the weak induction of forces.

Considering the usual TO-56 type encapsulation in the most used semiconductor laser diode in the market, Fig. 4a shows the direction of induction of force affecting an external object and Fig. 4b depicts the direction of the thrust of the laser diode structure considering the self-induction of force. Figs. 4a and 4b are part of Fig. 4. An example of a specific use of the invention relates to the self-induction of force and is shown as follows.

In Fig. 5 we diagrammatically show an usual laser pointer supplied via wires from an external voltage source (not shown) mechanically supported by a plastic platform. Finally, in Fig. 6 it is diagrammatically shown an usual laser pointer projecting an external induction of forces when emitting an orthogonal light laser beam. The figures are purely diagrammatic and not drawn to scale. This figure illustrates a device implemented for self-induction of force pointing upwards 5.5. The device is composed by a laser pointer 5.1 which is connected by wires 5.3 to a 3V external DC voltage source not drawn in the figure. The laser pointer 5.1 is supported on a horizontal platform 5.2 made of plastic. The self-induction of force in the vertical direction is generated when the laser pointer is emitting a 532nm wavelength light laser beam in the horizontal direction 5.4. It was possible to achieve up to 200mW in terms of output optical power. In this condition, the charge carriers move down in theactive region.

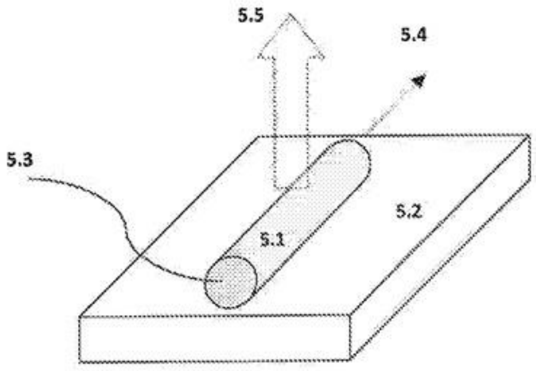

FIG. 5. Diagram of an usual laser pointer used in the experiments. The device projects an external induction of forces when emitting an orthogonal light laser beam.

The weight for this device is 73g where only a semiconductor laser diode with TO-56 encapsulation is used. Keeping with this same weight and size, it is possible to multiply the self-induction of force F per ten adding more for TO-56 type semiconductor laser diodes connected and mechanically aligned in the same electronic circuit. It is possible to drive a direct current almost twice higher for each laser diode to achieve this mentioned gain as well.

When the intensity of the self-induction of force generated by a semiconductor laser diodes surpass its own structural weight force on the ocean level, this device can be used to reduce significantly the load of the vehicles or carriers where it is linked mechanically.

In case of the device considered in Fig. 5, the direct current I must be equal to 38A in order for the self-induction of force to surpass its own weight force on the earth surface, but this value is far beyond the maximum operating limit.

Considering the space navigation, where the earth gravitational acceleration is significantly reduced, the device showed in Fig. 5 can be used as an impeller.

Some electrically pumped semiconductor laser diodes in the scientific, industrial and professional market with other kinds of encapsulations can use a direct current higher than1 A. But, carbon dioxide lasers are most often used in cases where highest-power applications are needed instead of semiconductor laser diodes because of some difficulties to control the state of semiconductors in high temperature, for example. This new use related to self-induction of force encourages the development of electrically pumped semiconductor laser diodes with higher-power level than used in carbon dioxide lasers.

A second specific use of the invention is related to the induction of force in external objects and is shown as follows: regarding the same laser pointer 5.1 used in the device shown in Fig. 5, the calculation to find the self- induction of force *F* intensity is the same is the induction of force in external objects. This force is equal to 2×10^{-5} N considering the same laser pointer with the same parameters mentioned before, that is, a 200 mA direct current *I*, a 400 resonant cavity gain *G* and the magnetic constant $4\ \pi x\ 10^{-7}$ H/m.

The intensity of this force is strong enough to be detected by an accelerometer with 0.000596 m/s^2 resolution and 48g weight located in some distance. It is considered a negligible divergence of the projection of induction emerging from the resonant cavity of the semiconductor laser diode with 400 μm length. This geometric projection of induction of force is intercepted by the accelerometer and it passes through any means considering the nature of the generalized quantum entanglements. This property can be really useful.

Fig. 6 shows a laser pointer 6.1 projecting an induction of force 6.2 through a massive, thick and opaque wall 6.3. This laser pointer 6.1 is the same as that shown in Fig. 5.1, but using two internal batteries providing a 3V DC voltage. The accelerometer 6.4 is placed in the other side of the wall 6.3 and it is intercepted by the induction of force projection. The induction of forces is detected by the accelerometer 6.4 and a negative or positive acceleration is registered according to the direction pointed by the force 6.2. This direction pointed by the force 6.2 depends on the direction of the direct current in the resonant cavity of the semiconductor laser diode used in the laser pointer 6.1. The position of the laser pointer 6.1 must be adjusted to ensure that the induction of force projection achieves the accelerometer 6.4 accordingly. Two points separated by the wall 6.3 can be marked with precision. The arrow 6.5 shows a light laser beam orthogonal than the induction of force projection.

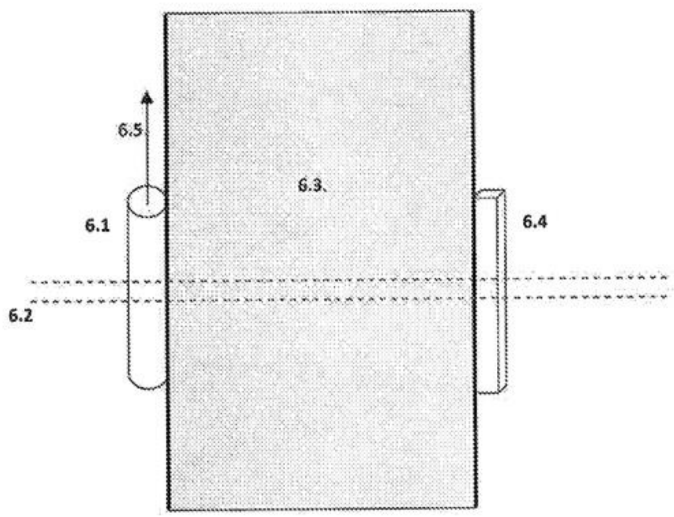

FIG. 6. Scheme of a laser pointer projecting an induction of force through a massive, thick and opaque wall.

The setup shown in Fig. 6 can be used for metrology considering the actual difficulties to mark two or more points that need to be geometrically linked by a straight line in the huge and massive structures where it cannot be crossed by a light laser beam.
Currently the methodology for this procedure is expensive, inaccurate and time consuming, considering that many external sensors are used around the structure where the measurements are made indirectly.
The summary of these specific uses of such inventions is that the first utilizes the usual semiconductor laser diodes as impellers in the outer space via self induction of force and which can be upgraded for use on the

earth's surface and the second one utilizes the semiconductor laser diodes as tools for metrology using the property related to the induction of force in external objects.

IV. CONCLUSION

In this work, we present our experimental and theoretical investigations concerning to the existence of a field of anomalous forces on the neighborhood of a semiconductor laser diode in operation. The nature of such forces is still unknown up to present date, but our work shows that GQE hypothesis is consistent to explain the effects experimentally verified.

Considering some macroscopic observables considered from microscopic quantum entanglements among momentum carriers and outer particles, we show that the magnitude of the so called anomalous forces can be calculated via equations using classical quantities. In fact, the theoretical results show that such a concept can explain with reasonable accuracy the majority of the experimental data. Our experimental results show that we got to measure detectable values of external forces generated by the operation of the semiconductor laser diode. It is possible to improve the experimental conditions and instruments or devices in order to obtain more profound results and evidences of the phenomenon.

We also applied the theoretical proposal known as GQE early successfully applied to other systems as magnetic dipoles of magnetic cores, electric dipoles of capacitors, superconductors or piezoelectric materials - and showed that it can explain in a consistent way the experimental results for the invention based on the laser diodes.

We from now on aim to investigate new devices with different materials and powers or other possible configurations as associations of lasers that could enhance the interaction so that one can effectively use them in technological applications. Besides, it would be convenient also to report that we are elaborating other works based on new experimental setups that involve the detection of higher magnitudes of the anomalous forces and the effect of induction of nonlocal forces at distance.

In summary, it is well known that the electrically pumped semiconductor laser diodes find wide use through their high coherent light emission. Surprisingly, these devices can be used like force inductors and such an induction is not caused by the laser beam, but is caused by the highly ordered flow of the charge carriers through the internal resonant cavity and its mutual coupling with the external environment.

The highly ordered state of the charge carriers is caused by the stimulated emission of photons above the lasing threshold state. An innovative feature is that there is a coupling between these highly ordered charge carriers and the external environment via widely existing quantum entanglements. Properly adjusting some parameters such as the intensity of the direct current in the diode, current direction, resonant cavity geometry and gain (density of charge carriers in semiconductor regions n and p), it is possible to control the force inducted in the external targets or the thrust self-induced in the laser diode structure.

At last, we assert that the results are good enough to conclude the existence of the anomalous forces, but more tests need to be realized in order to fully characterize the effect in controlled environments.

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