



# Pulsed Intense-field Lasers Can Evoke EEG Contactlessly and Noninvasively, Which Might Become a Means of Manipulating Consciousness or Behaviors Remotely

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**Abstract:** *Background:* The idea of remotely manipulating other people or animals without contact or invasion has existed long time ago. Many people have tried, but no one really make it happen. Recently, the technique of Brain-Computer interfacing is mushrooming. It was said researchers had partially realized the direct communication with brain and even the manipulation of the subject's behavior via a chip embedded in the brain. Nevertheless, for the trauma of implantation, such chip-intrusive method is not favorite to the healthy people. *Objective:* To explore a contactless and noninvasive technique to remotely manipulate the consciousness and behaviors of animals or humans. *Methods:* The anesthetized mice or sciatic nerve samples were caged in an air-filled bottle and set as the target. A pulsed intense-field laser (PIFL) beam ( $\lambda=532$  nm;  $P=20$  TW;  $E=0.1$  J/cm<sup>2</sup>; pulse width=30 fs;  $f=1$  Hz) was emitted to the targets 1.2 m away. *Results:*  $\theta$ -Rhythm mouse brain waves were evoked and recorded, and potentials in the detached frog sciatic nerve were stimulated without contact or invasion. *Conclusion:* The experiments shown that Pulsed Intense-field Lasers can evoke EEG and potentials in nerves contactlessly and noninvasively. It inspired us that we can remotely manipulate consciousness or behaviors on animals or humans by PIFL, which might bring about development to the Information Science and provide new medical treatment.

**Keywords:** Pulsed Intense-Field Lasers, Remote Manipulation of Consciousness and Behavior, Sciatic Nerve-Gastrocnemius Model, EEG

## 1. Introduction

Whether fantasy or reality, for justice or for evil, the idea of remotely manipulating other people or animals without contact or invasion has existed since time immemorial [1-5], and many people have tried to make it happen. Legends have that Chinese Qigong (a mysterious Chinese Kung Fu) masters could cure diseases with their minds or drive the people lived

thousands miles away to move [6-11]. However, no one has ever witnessed such an event.

Physiologically, the movements of ions and transmitters intra and inter neurons are the basis of nerve excitation, and the transmission of ions and transmitters may result in muscle contraction, organ function or consciousness [12, 13]. In recent years, scholars have tried manipulating the flight direction of pigeons or the limb activity of patients by

transmitting electrical signals to chips embedded in the brain [14-16]. Others have activated cortical neurons and accelerated associative learning in mice via an opening in or thinned area of the skull using mid-infrared rays [17]. However, the risk to life of traumatic craniotomy instrument implantation is unfavorable for treatment. Noninvasive and remote manipulation techniques in animals and humans are urgently needed but have not yet emerged. Magnetic and electric fields have been used to evoke potentials in detached nerves or tissues *in vivo* [18-21]. However, emitted magnetic fields diverge, which limit their use for precise neuron control.

A pulsed intense-field laser (PIFL) can excite proton waves and electromagnetic pulses (EMPs) [22, 23]. Particularly, the excited protons can drive the ions in the target to move with little disturbance to the objects in the pathway [24-26], much less to the low-density skeleton. Here, an IFPL device at the Shanghai Institute of Optic Mechanics (SIOM, Chinese Academy of Sciences) was used to induce potentials in a detached frog sciatic nerve from 1.2 meters away.  $\theta$ -rhythm brain waves in mice were successfully evoked contactlessly and implantlessly for the first time, which greatly inspired us to explore methods to remotely manipulate the behavior and conscious of humans and animals.

## 2. Materials and Methods

### 2.1. Materials

Toads were purchased from the market, and the sciatic nerve-gastrocnemius model was prepared according to animal welfare and ethics guidelines. Four-week-old BALB/c mice were obtained from the Experimental Animal Center of Wenzhou University.

### 2.2. Instruments

An electrophysiological recorder (BL-420N, Techman Soft, Inc., Chengdu, China) was used to record the neuronal electrical signals. A digital electroencephalography (EEG) topographic map recorder (EK-8200, Ekane Electronic Technology Co., Ltd., Xuzhou, China) was used to record EEG signals from the scalp. The IFPL (Alpha 5/XS Ti Sapphire Laser;  $\lambda=532$  nm;  $P=20$  TW;  $E=0.1$  J/cm<sup>2</sup>; pulse width=30 fs; JADE2 pumping; frequency=1 Hz) at SIOM was used to excite the potentials in the sciatic nerve and elicit the brain EEG signals.

### 2.3. Sample Container and Signal-recording Circuit Preparation

The target chamber was under vacuum ( $1.0 \times 10^{-9}$  Pa) during the experiment. To prevent death of the biological samples, the sciatic nerve-gastrocnemius model or mouse was placed in a tightly sealed and atmosphere-filled glass bottle, and the signals were acquired by electrodes linked to the extravehicular EEG or neuronal electrical signal recorder (Figure 1). An infrared camera was placed near the glass bottle to observe the state and behavior of the samples.

The electrode set was placed on the scalp of the mouse, which was sealed in an air-filled bottle, and was connected to

the extravehicular scalp EEG signal recorder through the flange on the wall of the vacuum chamber.

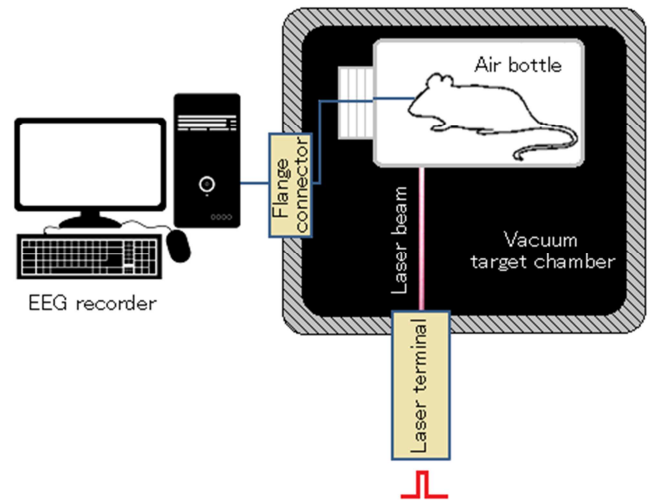


Figure 1. Sample container.

### 2.4. Stimulating the Sciatic Nerve-gastrocnemius Model with the PIFL

The sciatic nerve-gastrocnemius of the toad was stripped and moistened with Ren's solution to maintain activity. Then, it was laid on the recording electrode linked to the extravehicular physiological signal acquisition system (PSAS) and tightly sealed in an air-filled bottle in the vacuum target chamber. A single laser pulse was emitted. The laser-induced electrical signals in the nerve were recorded by the PSAS, and the sciatic nerve-gastrocnemius was photographed by a camera.

### 2.5. Evoking Mouse EEG Signals with the PIFL

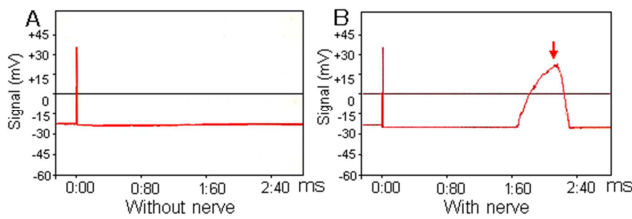
Five mice were individually anesthetized by an intraperitoneal injection of 20  $\mu$ l of 2% uratan to ensure that they did not move during the test. The first electrode was placed in the upper right position of the skull (C3, shown in Figure 3-A); the second electrode was connected to the middle position above the skull (central zone, CZ), and the third electrode was clamped to the left ear (A1). After the electrode-connected head cover was fastened to the mouse and the mouse was placed into the well-sealed, air-filled glass bottle, the electrodes were connected to the scalp EEG signal recorder outside of the chamber, as shown in Figure 1. After the vacuum was achieved in the target chamber, a single intense-field laser pulse was emitted. The laser-evoked scalp electrical signals were recorded.

## 3. Results

### 3.1. PIFL-stimulated Potentials in the Sciatic Nerve

As shown in Figure 2-A, no signals were recorded from the electrode not connected to the nerve fibers even after the laser pulse was emitted (the peak at 0 ms is an artifact stimulated by

the laser pulse).



**Figure 2.** PIFL-stimulated neuromotentials.

A) The vacant electrode recorded only a laser-triggered perturbation pulse at 0 seconds, and no signals were. B) From the nerve fiber-connected electrode, a 27-mV evoked potential (lasting 0.8 ms) was recorded at 1.6 ms after the pulse was emitted ( $n=6$ ).

In contrast, from the nerve fiber-connected electrode, a 27-mV evoked depolarized and overshoot potential (lasting 0.8 ms) was recorded at 1.6 ms after the laser pulse (Figure 2-B, indicated by the red arrow “↓”). The test was repeated on 6 toads, and all tests were successful. Obviously, the laser pulse stimulated potentials in the sciatic nerves, and the more alive the tissue was, the more intense the signal.

### 3.2. PIFL-evoked EEG Signals

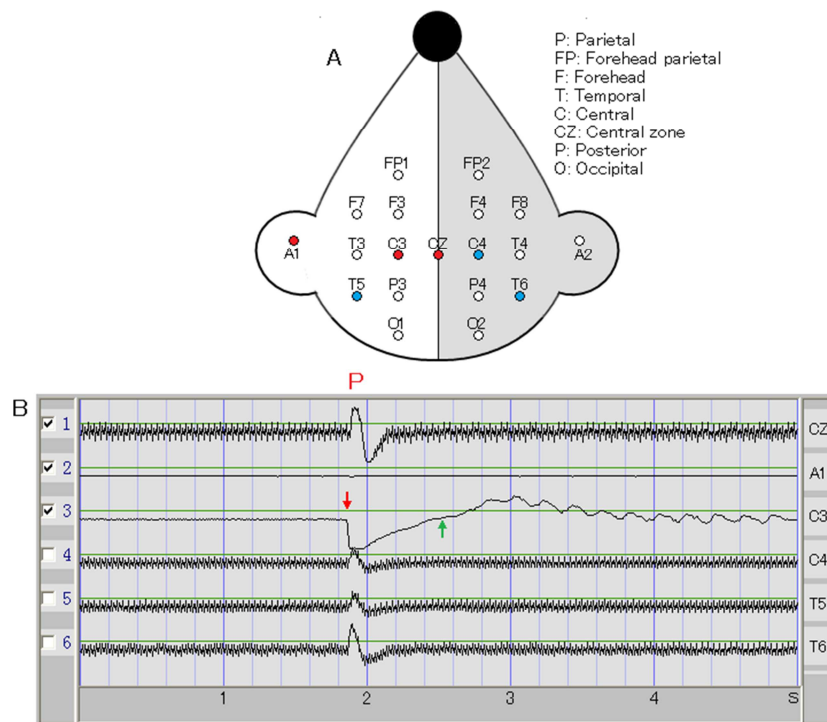
As shown in Figure 3, before the laser pulse was emitted, only a low-amplitude chaotic resting potential (the frequency was approximately 20 Hz) was recorded by the electrodes

connected to the mouse scalp (lane 3 in Figure 3-B). After the laser pulse was emitted (indicated by “P” and the red arrow “↓” at 1.9 seconds), the 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> electrodes, which had no contact with the scalp, recorded first a positive and then a negative fluctuation. The whole procedure lasted 0.15 seconds, after which the resting state returned. No further evoked signals were recorded.

In detail, lane 1, which was connected to the brain via the middle of the scalp (CZ), under which is the nerve-free superior sagittal sinus, recorded the same positive and then negative wave as that from the nonloaded electrodes (4, 5 and 6), except that it was a slightly stronger wave.

The signal from lane 2, which was connected to the left ear (A1), remained constant most of the time, except for a weak negative fluctuation at the moment of the laser pulse.

Lane 3, which recorded the signal from the electrode making contact with the left central scalp (C3), displayed a negative overshoot wave at the moment of the laser pulse and then depolarized. It should be noted that, 0.8 seconds after the laser pulse (at 2.57 seconds, indicated by the green arrow “↑”), the voltage overshoot reversed. When the maximum (+3  $\mu$ V) was reached, a  $\theta$ -rhythm brain wave with an amplitude of 5  $\mu$ V and frequency of 5 Hz followed. That is, the IFPL excited the brain without contact or an implanted apparatus, showing potential for use as a remote interventional method.



**Figure 3.** PIFL excites EEG signals via a contactless and implant-free method.

A) Location of the electrodes on mouse skull. The red spots indicate the connections to the scalp, where EEG signals were individually recorded. The other spots were vacant. B) PIFL-excited EEG signals in the mouse brain from 1.2 meters away elicited without contact or an implanted apparatus. Lane 3 (C3) shows the PIFL-excited 5-Hz  $\theta$ -rhythm brain wave in the mouse brain. Lane 1 was connected to the central zone (CZ) of the mouse brain, lane 2 was connected to the left ear (A1), and lanes 4, 5 and 6 were connected to the vacant electrodes; these lanes recorded only low-amplitude chaotic resting signals. All mice survived after the tests ( $n=5$ ).

## 4. Discussion

It is well known that  $K^+$  and organic  $A^-$  ions are abundant in the intracellular fluid, while  $Na^+$  and  $Cl^-$  ions are abundant extracellular. The ion concentration between the inner and outer parts of the cell is uneven, and due to the concentration difference, there is a difference in potential across the cell membrane [27, 28]. Without external stimulation, the resting potential will remain relatively stable [27-29].

PIFLs can excite proton waves and EMPs, and the induced EMPs can drive ions to move [22, 23, 30]. Therefore, it is reasonable that when the laser pulse is strong enough and by the channels on the nerve membrane, the ions inside and outside the neuron membrane will be caused to flow to the opposite side, which consequently produce a transient potential fluctuation that spreads along the neuron, and finally excite the neuron [31-33]. The potentials can be recorded by a PSAS or EEG system [31-33]. In particular, PIFLs can drive the ions in the target cell via the Bragg effect without disturbing objects in the pathway [24-26], this ensured the target be stimulated effectively with enough energy. At present, the IFPL-based contactless and noninvasive EEG evoked technique we explored is just the beginning, much developments need to be furthered. For example, we can try to use multi miniaturized PIFL terminals to synchronously stimulate neurons under the cranium in different regions and at different depths. By stimulating each neuron with signal-coded laser pulses, can there appear an artificial illusion or something else such as artificial memories or artificial ideas. With it, may the directly transmit information to the brain from outside be realized, if this works, it will greatly promote the progress of Information Science. In any case, with this method, brain activity can undoubtedly be intervened.

Health is always a concern for people. Patients who suffer from spinal cord or motor neuron injuries (for example, Stephen Hawking, the greatest theoretical physicist in contemporary Britain, suffered from amyotrophic lateral sclerosis), are confined to wheelchairs or beds for their entire lives. Physiotherapy has been employed for their neuromuscular functional recovery, for physical (magnetical, electrical, thermal) stimulation can induce the production of neurokines [31] which prevents their neuromuscular atrophy [32]. Guan and Austin described that a laser pulse can induce electrical signals in nerves and evoke muscle contractions [33, 34]. If such a method is applied in the clinic, it might do help to the patients with spinal injury for their recovery.

However, in addition to the limited maturity of the technique, PIFLs may be somewhat ionizing and may cause damage to the body [35-38]. Although all of the mice survived after our tests, to ensure the safety of this method in the clinic, more intensive investigations (including of safe doses and targeted stimulation) are needed.

## 5. Conclusion

Pulsed Intense-field Lasers can evoke EEG and potentials

in nerves contactlessly and noninvasively. It provided an potential method to remotely manipulate consciousness or behaviors on animals or humans, which might bring about profound development to the Information Science and medical treatment.

## Abbreviations

NRMCB: Noninvasive and Remote Manipulation of Consciousness and Behavior; PFPL: Pulsed Intense-Field Laser; EEG: Electroencephalography, EMP: Electromagnetic Pulse.

## Disclosures

The authors have no relevant financial interests in this article and no potential conflicts of interest to disclose. The animal experiments were performed in strict accordance with the Guidance for the Care and Use of Laboratory Animals of the National Institutes of Health, and the protocol was approved by the Committee on the Ethics of Animal Experiments of Taizhou University (Permit Number: 15-1523).

## Data and Materials Availability

Devices unique to the lab, or any purchased materials critical to the results reported in the paper.

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## References

- [1] Andre Zaitsev, reindeer camp in Murmansk border region [J], Murmansk, May 8, 2013 [J]. (in Russian).
- [2] Russian soldiers train in sub-zero temperatures with reindeer, BBC, 4 February 2016.
- [3] The Geographical, Natural and Civil History of Chili, Longman, 2012, 2: 15-16.
- [4] Falvey, John Lindsay. Introduction to Working Animals. Melbourne, Australia: MPW Australia, 1985.
- [5] Finley, Jameson argues in favour of a very large use of slaves, Wood disputes it, 1983 and 1988. 1997, p150.
- [6] Tracking the Outcome of Chinese Qigong Masters at the End of the Last Century, <https://tieba.baidu.com/p/2331021997>. (in Chinese).
- [7] Zhang Yusheng is a Qigong master who treats diseases with supernatural powers, <https://www.xzbu.com/6/view-2827178.html>. (in Chinese).

- [8] Focus: Ufology in mysticism. China Daily (HK Edition), 12 December 2003.
- [9] Goldstein, Michael J. Alternative Health Care. Temple University Press, 1999.
- [10] Jonas, Wayne B, Crawford, Cindy, Healing, intention, and energy medicine: science, research methods, and clinical implications. Edinburgh: Churchill Livingstone, 2003.
- [11] Moyers, Bill, Healing and the Mind, Main Street Books, 1995.
- [12] Nishino A, Baba SA, Okamura Y, A mechanism for graded motor control encoded in the channel properties of the muscle ACh receptor [J], Proc Natl Acad Sci U S A, 2011, 108 (6): 2599-604.
- [13] Hnik P, Vejsada R. Neuromuscular transmission in some hindlimb muscles of piglets with congenital myofibrillar hypoplasia (splayleg) [J], Physiol Bohemoslov, 1979, 28 (5): 385-92.
- [14] New achievements of Shandong University: Pigeons wear controllers and act under command, Chutian Metropolitan Daily. 2007.2.27. <http://news.sohu.com/20070227/n248378472.shtml>, (in Chinese).
- [15] Brain-like chips based on silicon material (CMOS) support pulse neural network (SNN), Chinese Science: Information Science [J], 2015, 2: 1129-1132, (in Chinese).
- [16] Dethier J, Nuyujukian P, Eliasmith C, Stewart T, Ellassaad SA, Shenoy KV, Boahen K. A Brain-Machine Interface Operating with a Real-Time Spiking Neural Network Control Algorithm [J], Adv Neural Inf Process Syst., 2011, 2011: 2213-2221.
- [17] Zhang J, He Y, Liang S, Liao X, Li T, Qiao Z, Chang C, Jia H, Chen X, Non-invasive, opsin-free mid-infrared modulation activates cortical neurons and accelerates associative learning [J], Nat. Commun., 2021, 12 (1): 2730.
- [18] Li G, Biomagnetism and Its Applications [J], Science Press, 1987 (z1): 139-144, (in Chinese).
- [19] Ram Rakhyani AK, Kagan ZB, Warren DJ, Normann RA, Lazzi G. A  $\mu\text{m}$ -Scale Computational Model of Magnetic Neural Stimulation in Multifascicular Peripheral Nerves [J], IEEE Trans Biomed Eng., 2015, 62 (12): 2837-49.
- [20] Khedr EM, Aref EE. Electrophysiological study of vocal-fold mobility disorders using a magnetic stimulator [J], Eur J Neurol., 2002, 9 (3): 259-67.
- [21] Yu H, Wang Y, Zheng C, Modeling for activating peripheral nerves by transverse electric field [J], Sheng Wu Yi Xue Gong Cheng Xue Za Zhi, 2005, 22 (5): 865-9, (in Chinese).
- [22] Lieselotte Obst-Huebl, Tim Ziegler, Florian-Emanuel Brack, João Branco, Michael Bussmann, Thomas E Cowan, Chandra B Curry, Frederico Fiuza, Marco Garten, Maxence Gauthier, Sebastian Göde, Siegfried H Glenzer, Axel Huebl, Arie Irman, Jongjin B Kim, Thomas Kluge, Stephan D Kraft, Florian Kroll, Josefine Metzkes-Ng, Richard Pausch, Irene Prencipe, Martin Rehwald, Christian Roedel, Hans-Peter Schlenvoigt, Ulrich Schramm, and Karl Zeil, All-optical structuring of laser-driven proton beam profiles [J], Nat Commun., 2018, 9: 5292.
- [23] Dubois JL, Rączka P, Hulin S, Rosiński M, Ryć L, Parys P, Zaráś-Szydłowska A, Makaruk D, Tchórz P, Badziak J, Wołowski J, Ribolzi J, Tikhonchuk V, Experimental demonstration of an electromagnetic pulse mitigation concept for a laser driven proton source [J], Rev Sci Instrum., 2018, 89 (10): 103301.
- [24] Fuggetta G, Fiaschi A, Manganotti P, Modulation of cortical oscillatory activities induced by varying single-pulse transcranial magnetic stimulation intensity over the left primary motor area: a combined EEG and TMS study [J], Neuroimage, 2005, 27 (4): 896-908.
- [25] de Vera P, Abril I, Garcia-Molina R, Energy Spectra of Protons and Generated Secondary Electrons around the Bragg Peak in Materials of Interest in Proton Therapy [J], Radiat Res., 2018, 190 (3): 282-297.
- [26] Sayyed Bijan Jia, Mohammad Hadi Hadizadeh, Ali Asghar Mowlavi, Mahdy Ebrahimi Loushab, Evaluation of energy deposition and secondary particle production in proton therapy of brain using a slab head phantom [J], Reports of Practical Oncology & Radiotherapy, 2014, 19 (6): 376-384.
- [27] Shapiro HM. Cell membrane potential analysis [J], Methods Cell Biol. 1994; 41: 121-33.
- [28] Guo L, Perspectives on electrical neural recording: a revisit to the fundamental concepts [J], J Neural Eng. 2020; 17 (1): 013001.
- [29] Gernot R, Müller-Putz, Electroencephalography [J], Handb. Clin. Neurol., 2020; 168: 249-262.
- [30] Gong X, Li J, Guo C, Xu K, Yang H, Molecular switch for tuning ions across nanopores by an external electric field [J], Nanotechnology. 2013; 24 (2): 025502.
- [31] Fang JQ, Fang JF, Liang Y, Du JY, Electroacupuncture mediates extracellular signal-regulated kinase 1/2 pathways in the spinal cord of rats with inflammatory pain [J], BMC Complement Altern Med. 2014; 14: 285.
- [32] Yang J, Min S, Xie F, Chen J, Hao X, Ren L, Electroacupuncture alleviates neuromuscular dysfunction in an experimental rat model of immobilization [J], Oncotarget. 2017 8 (49): 85537-85548.
- [33] Guan T, Zhu, K, Chen F, He Y, Wang J, Wu M, Nie G, Auditory nerve impulses induced by 980 nm laser [J], J Biomed. Optic. 2015, 20 (8): 088004.
- [34] Austin R. Duke, Jonathan M. Cayce, Jonathan D. Malphrus, Peter Konrad, Anita Mahadevan-Jansen, and E. DucoJansen, Combined optical and electrical stimulation of neural tissue in vivo [J], J. Biomed. Optic. 2009; 14 (6): 060501-2.
- [35] Karu TI, Fedoseeva GE, Iudakhina EV, Effect of low-intensity periodic-impulse laser UV radiation on the nucleic acid synthesis rate in proliferating and resting cells, Tsitologiya, 1983, 25 (10): 1207-12.
- [36] Sato K, Nishikino M, Kawachi T, Shimokawa T, Imai T, Teshima T, Nishimura H, Kando M. laser-plasma-produced soft X-ray laser at 89 eV generates DNA double-strand breaks in human cancer cells [J], J Radiat Res., 2015, 56 (4): 633-8.
- [37] Kazuhisa NAKAJIMA, Laser-driven electron beam and radiation sources for basic, medical and industrial sciences [J], Proc Jpn Acad Ser B Phys Biol Sci., 2015, 91 (6): 223-245.
- [38] Jianhui Bin, Klaus Allinger, Walter Assmann, A laser-driven nanosecond proton source for radiobiological studies [J], Applied Physics Letters, 2012, 101: 243701.