Why FlexBeam?

Scientific substantiation for FlexBeam Red Light Therapy device

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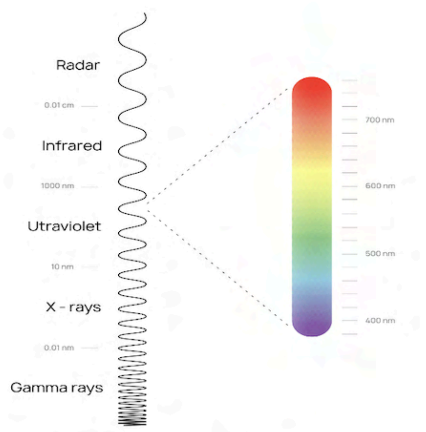
Introduction to FlexBeam

The FlexBeam is a portable Targeted Red Light Therapy device that emits non-coherent red and near infrared light using LEDs. This phototherapy is referred to as Photobiomodulation (PBM) in medical science.

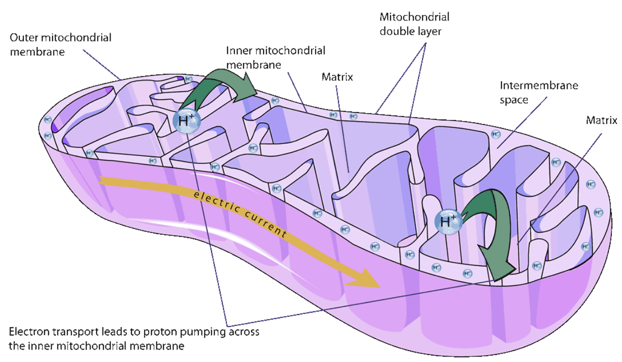
Red Light therapy devices typically use either laser diodes or LED diodes generating light in the same wavelengths as the light coming from the sun. All the cells in our body have evolved to absorb and use natural light that we get from the sun in the form of electromagnetic radiation.



Electromagnetic Spectrum of Light

These wavelengths are essential for our bodies, as various cells absorb light to aid multiple processes. We source this energy daily, just like plants do when photosynthesizing light.

Our body consists of 37 trillion cells, and each cell runs approximately 100,000 chemical reactions per second. Since powering this activity requires a high amount of energy, the cells have learned to cooperate with a symbiotic mitochondrion.

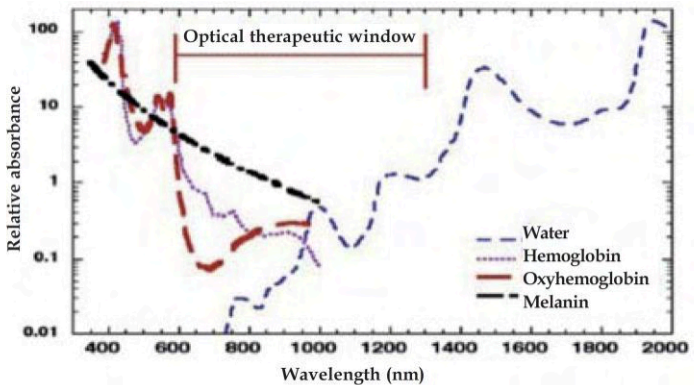


Mitochondria generate energy in our cells, by producing ATP, which breaks down and releases energy. We make 10 billion ATP molecules each day to generate a remarkable 1200 watts! This is what powers all the activity in our body.

Red, in combination with infrared, light takes up more than 50% of all solar radiation. Red light is visible to the human eye and absorbs at the skin surface. Infrared is invisible and penetrates deep into the body. Infrared light typically feels warm, like sitting next to a campfire. During the daytime we are exposed mostly to blue and ultraviolet light, the latter is useful for vitamin D synthesis.

Different cells absorb light in different wavelengths, for example, blood haemoglobin highest absorption happens in the blue or green light spectrum.

Light absorption in the mitochondria can only happen in the narrow "optical" window. Use of Red Light almost exclusively involves red and near-infrared light within the range of 600–1100nm, where light in the red (R) 635-700nm and near infrared (NIR) 760-1100nm regions has been studied extensively. Water also absorbs photonic energy in much longer wavelengths, mid to far infrared.

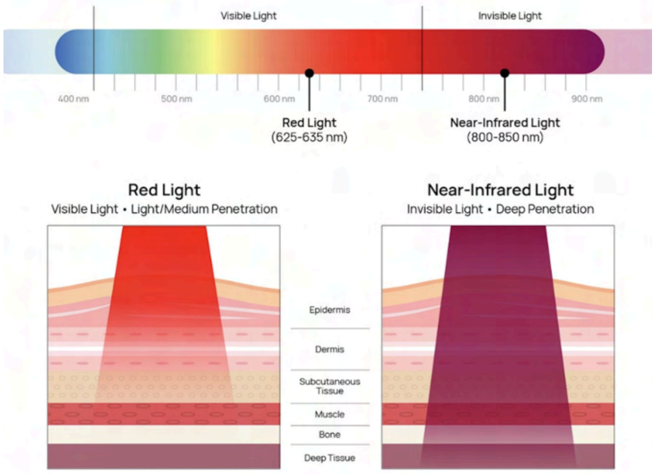


The wavelengths in the red and near-infrared range are frequently known collectively as 'red light', and the therapy that utilizes these wavelengths is known as Red Light Therapy (RLT). Red Light Therapy does not employ a thermal mechanism, but rather has a photochemical effect. This bio-stimulating effect is typically referred to as Photobiostimulation, and it causes physiological changes on a cellular level, that is why it is called Photobiomodulation (PBM). It is important to understand they have to be at low energies, unlike high-powered medical lasers that are used in hospitals for a different purpose, for example to cauterize blood vessels or tissue.

Most important change concerns stimulation of energy production in the mitochondria. The majority of pathological processes in the cell are due to dysfunctional mitochondria, when the cell is in anaerobic function mode, leading to poor energy production, acidosis and cellular dehydration. Interestingly, it is also associated with a low membrane potential and typically found in degenerative processes and cancer, which suggest a possible link between these detrimental processes and low cellular energy.

The Cytochrome C Oxidase (CCO), light absorbing chromophore facilitates the last step of ATP production in the mitochondria. This chromophore absorbs light in the range between 570nm to 850nm.

FlexBeam operates within a range of 625~635nm in red and 800~830nm in near infrared spectrum, corresponding to primary absorption of photons of light in the IV complex of the respiratory chain, therefore directly stimulates energy processes in the cells of the tissues being irradiated.



There is another very important effect from RLT, a release of Nitric Oxide (NO). NO that is produced in the mitochondria can inhibit respiration by binding to CCO and competitively displace oxygen, especially in stressed or hypoxic cells. When exposed to red and near infrared light, CCO acts by absorbing light photons and pushing off NO, so NO cannot have an inhibitory effect on it, allowing CCO to recover and resume cellular respiration. Nitric Oxide has a vasodilation property that stimulates microcirculation. Increased Nitric Oxide concentration measured in cell culture has beneficial effects on cell-signalling pathways.

In addition to mitochondria, there are other light receptors engaged in photo activation: NHDA, light gated ion channels, opsins, flavins, flavoproteins. Red light energy is absorbed by these receptors, increasing electron transfer across the mitochondrial membrane via a cascade of reactions, resulting in increased charge, which leads to more available energy throughout the body.

Reactive Oxygen Species, like cyclic AMP, NO and Ca2+, which are also released in small quantities after exposure to RLT, activate numerous signalling pathways, leading to activation of transcription factors. These transcription factors result in increased expression of genes promoting protein synthesis, cell migration and proliferation, anti-inflammatory signalling, release of anti-apoptotic proteins, and antioxidant enzymes. Stem cells and progenitor cells appear to be particularly susceptible to RLT.

Light photons are also absorbed by water, which is abundant in the body, structuring water molecules creating so-called Exclusion Zone (EZ) water. Increase in EZ water around each cell contributes to an increase of charge, making water act like a battery. Infrared light could excite cells through water absorption, affecting the plasma membrane and altering the electrical capacitance.

Red light interaction optimizes the body at the cellular and tissue level - however, each cell responds to this light-interaction differently, resulting in biomedical effects diversity.

What do we know today about Near-Infrared Light?

Since ancient times people have been drawn to sunrise and sunset, where soothing light pacifies and prepares eyes for daytime stimulation or nighttime relaxation. Scientists have discovered that Melatonin release is specific to the Near-Infrared spectrum.

Although most people think of Melatonin as a sleep mediator, latest research suggests Melatonin is a potent antioxidant and is directly implicated in the free radical theory of aging. It has been shown to delay age-related increases in lipid peroxidation and oxidative damage, to protect the hepatic mitochondrial respiratory chain,and to impact the immune system. Zhao J. et al. demonstrated positive effects from red-light illumination and higher melatonin levels.

In fact, it might be that Melatonin is a potential mediator of red light's therapeutic effects. Melatonin is a hormone that regulates the circadian rhythm. Multiple studies show that Melatonin might be a principal component of red-light therapy.

Zimmerman et al. 2019 produced interesting research stating, in addition to nocturnal release of Melatonin into the bloodstream via the pineal gland, there is a *subcellular* generation of Melatonin specific to NIR day light exposure that serves a purpose of cellular protection against ROS accumulation due to mitochondrial activity.

In contrast, stimulation from mid to far Infrared light range produces thermal effects due to high absorption of photons by water molecules in the body. This principle is used in infrared saunas and heaters.

Benefits of RLT

Since 1967, thousands of randomized, double-blind, placebo-controlled, clinical trials (RCTs) have been published and supported by thousands of laboratory studies investigating the primary mechanisms and the cascade of secondary effects that contribute to a range of local tissue and systemic effects. Google Scholar already lists over 550,000 peer-reviewed papers on Red Light Therapy & LLLT Benefits. There have been a large number of both animal model and clinical studies demonstrating highly beneficial PBM effects on a variety of diseases, injuries, and has been widely used in both chronic and acute conditions.

Beneficial therapeutic outcomes defined in Anders et al. were varied, including but not limited to:

- Alleviation of pain
- Inflammation reduction
- Immunomodulation
- Promotion of wound healing and tissue regeneration
- Anti-aging

These was achieved largely due to following physiological impacts from RLT:

1. Increase in cellular energy production (ATP, electron and proton flow)
2. Improvement in the local microcirculation and formation of new blood vessels
3. Stem cell production and maturation (osteoblast, fibroblasts, myoblasts, etc.)
4. Cellular proliferation in all types of tissue, collagen, muscular, bone, ligamentous, cartilage, nerve, soft tissue musculature, etc.
5. Improved collagen remodelling (III to I)

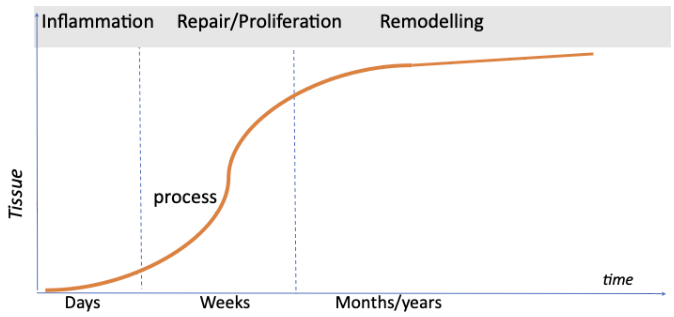
6. Numerous signalling pathways are activated via ROS, cyclic AMP, NO and Ca2+, leading to activation of transcription factors to increase expression of genes related to protein synthesis, cell migration and proliferation, anti-inflammatory signalling, anti-apoptotic proteins, antioxidant enzymes and ROS clearing (NIR)

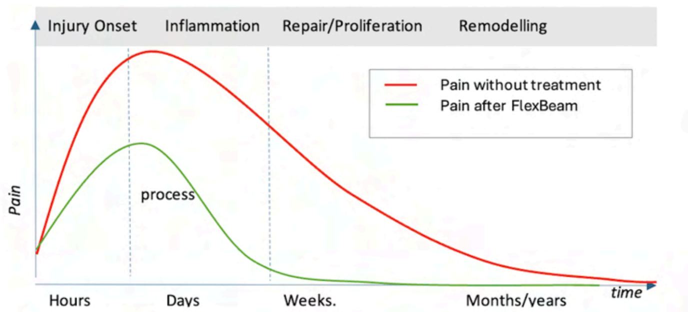
FlexBeam is a device that assists natural recovery because it creates an environment for better healing, working with the body and not against it. To understand this concept, please look into what is a natural healing response.

Phase 1 – Inflammation stage is energy demanding to sustain high metabolic rate.

RLT enhances local circulation via release of Nitric Oxide (NO). During this phase as a result of stimulation of mitochondrial respiration there is an increased electron transport and ATP production.

An increase in Mitochondrial Membrane Potential (MMP) results in tangible energy. Galvanotaxis (cellular motility) leads to active healing at the site of injury. Active angiogenesis (growth of new blood vessels) contributes to faster healing.





Phase 2 – Repair stage or time of cellular proliferation. At this stage there is an integration of damaged tissues via scar formation.

RLT activates stem precursor cells, satellite cells and enables cellular proliferation, increasing collagen production and decreasing collagen degradation and proliferation of fibroblasts, faster conversion from Collagen III to Collagen I.

Phase 3 – Remodelling. At this stage activation of fibroblasts, myoblasts, and osteoblasts to fuse damage and to form new functional tissues and to contract and reorganise scars. RLT is known to remodel scar tissue faster and restore damaged tissue. This phase can last up to 2 years. Using red and near infrared light aids natural recovery and often helps to speed up healing time.

There is also a physiological impact on faster physical recovery after intense sport exercises due to better energy in irradiated cells, better blood flow to the muscle and faster clearance from accumulation of lactic acid, as well as less chances for muscular damage.

FlexBeam is a recovery tool for pre-conditioning, sports performance, and recovery from DOMS.

Lasers versus LEDs

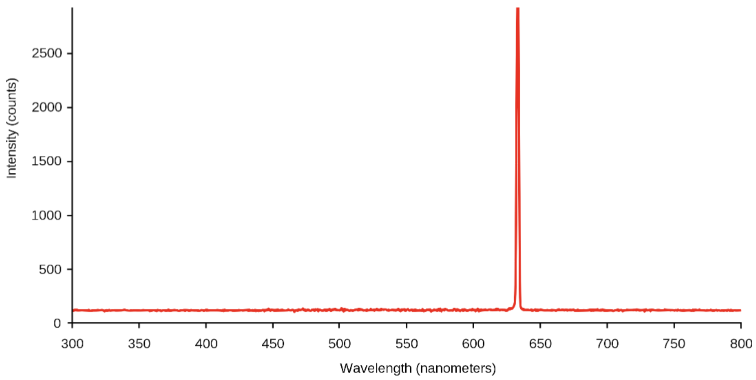
PBM in the past was largely associated with Low-Intensity Laser Therapy (LLLT), while the LED industry was in its infancy. Therefore, most research was on LLLT until the 90s when well-regarded institutions, such as NASA, discovered human health benefits while studying the impact of LEDs.

LED technology has a great potential compared to lasers due to its safety and low cost. The whole industry experienced an exponential growth in the last decade, increasing quality and efficiency of LEDs. Modern LEDs are not just GaAsP types, they are primary semiconductors. LEDs do not have a "voltage rating"; they are current driven. They are capable of delivering *more power with less heat*.

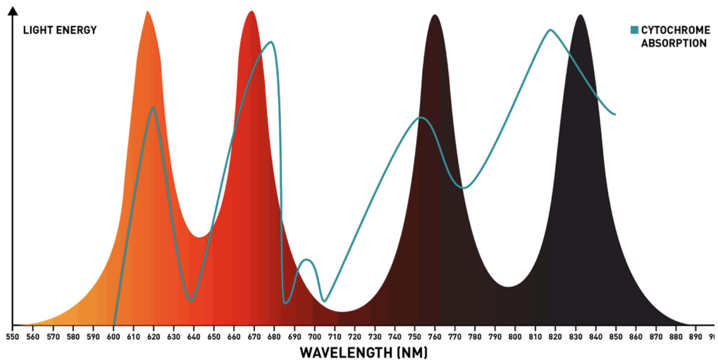
Michael Hamblin (PhD), a main researcher of PBM (lasers and LEDs), states: “inexpensive and safe light-emitting diodes (LEDs) has supplanted the use of expensive lasers in many indications. The better tissue penetration properties of NIR light, together with its good efficacy, has made it the most popular wavelength range overall.”

De Abreau Chavez et. al. compares the literature on LED vs laser for wound healing and concluded that “LED and laser promote similar biological effects, such as decrease of inflammatory cells, increased fibroblast proliferation, stimulation of angiogenesis, granulation tissue formation and increased synthesis of collagen” and “the biological effects are dependent on irradiation parameters, mainly wavelength and dose.”

Laser diodes produce a coherent light beam reaching the depth of tissue with less energy loss than other sources, however, this coherence is lost due to scattering. Lasers typically emit more intense and focused light compared to LEDs.



Non-coherent LEDs (with similar power) deliver a wider distributed beam, covering a bigger area, irradiating more tissue with no thermal effect. To achieve deeper penetration, high power LEDs are required, this is due to scattering and reflections being much greater with non-coherent light.

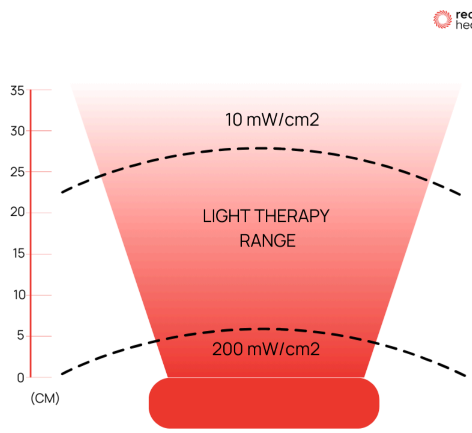


Concept of dosage

A significant amount of scientific and clinical literature was analyzed to establish the most effective parameters of RLT. However, it was acknowledged that there is no single parameter responsible for its effectiveness, but a combination of two crucial parameters: **Irradiation or Power density** and **Exposure Time or Dose**.

Dr Hamblin compares PBM with medication, where the medicine has a therapeutic property (wavelength of light), and the dose determines if it is effective or not (exposure time).

Irradiation or Power density, basically means how much power is distributed around a specific area: mW/cm^2 (or W/cm^2). Additionally, density is primarily affected by *the distance between the light source and the body*. The further away, the more it dissipates.



Exposure time defines how much energy the body received during a specific time: Energy (J) = Power (W) x time (s), it is also known as fluence. For a successful therapy this fluence must be sufficient, not too much and not too little.

The energy density expresses the total amount of energy delivered per unit area, in Joules per square centimetre (J/cm2). It is important to create energy density when you target a specific issue.

FlexBeam delivers the *effective dose* in all three programs that are designed to target the beam at the correct penetration depth. Each dose was calculated according to robust scientific research, so you do not need to work out irradiation, fluence and power density.

What makes the FlexBeam effective?

FlexBeam was designed after thorough analysis of scientific literature that exists today. All technical parameters are backed by peer-review research. This analysis demonstrated two interesting findings:

- There are some scientific papers that do not find a statistical significance in the outcomes. After scrutiny, there is a lack of disclosed technical parameters of the light source and its use, as well as inadequate dosing.
- There are some studies that are limited to testing PBM in-vitro, small laboratory animals or even cadavers, which of course, all have very different tissue properties to living human tissues. It is quite important to understand that living organisms, and human tissue, hold an electrical charge. In fact, every cell or water molecule in our organism has charge and polarity. This changes the way tissue responds to photonic stimulation.

FlexBeam features optimized time/dosage algorithms for safe and effective photo-stimulation. To reach deep-seated tissues like hip joints, high-power near-infrared light sources are necessary. Some LED-driven devices vary in strength, with some being weak and others comprising an array of weak LEDs. While some LED-driven devices may have high collective power, their distribution over a large area can lead to insufficient power density when compared to targeted, high-power density devices like FlexBeam. FlexBeam emits 100mW/cm2 in each of its six near-infrared LEDs and 50mW/cm2 in each of its three red LEDs, ensuring effective photonic energy delivery deep into tissue.

Laser beams are monochromatic and collimated, advantageous for specific applications like acupuncture. However, for irradiating areas affected by inflammation or degeneration, near-infrared LEDs with broader spectrum and power distribution are recommended. FlexBeam is designed for targeted light delivery, offering three stimulation cycles for varying penetration depths, visible red and near-infrared wavelengths, and flexible multi-angle delivery.

It is recommended that power density should not exceed 120mW/cm2 to avoid a bi-phasic dose response but should not be less than 50mW/cm2 for deeper penetration. Overdosing, while unlikely to cause damage, may result in less benefit than proper use. FlexBeam emits 100mW/cm2 in each of its six near-infrared LEDs and 50mW/cm2 in each of its three red LEDs.

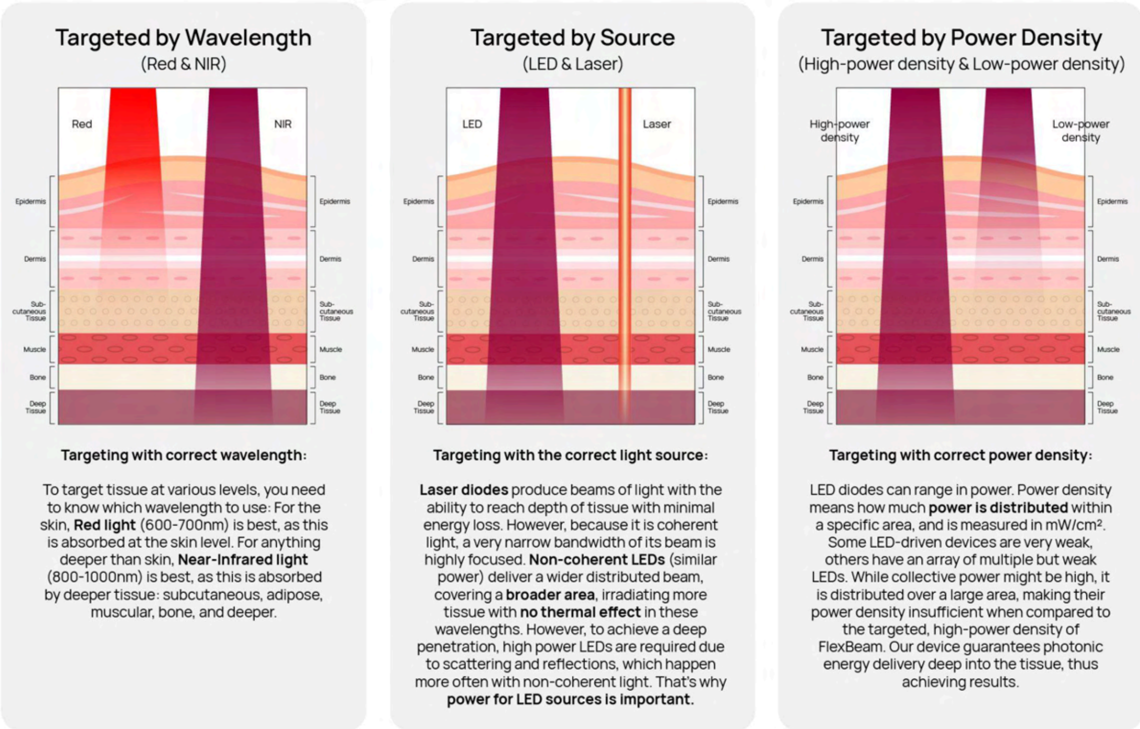
FlexBeam utilizes innovative features like "Sunrise & Sunset" Power Profiles™ for gentle stimulation. Innovative Recharge Wavelength Sweeping Functions™ integrated into the complex frequency pulsed signalling for maximum cellular responses within the range of 10-1000Hz and optimized time/dosage algorithms. Additionally, it offers a convenient wrap-around application, It is flexible to achieve targeted multi-angle delivery of light, battery or plug-in operation, and low EMF emission.

Notes on contributors

Dr. Zulia Valeyeva-Frost, MD, DCMAc. is an expert clinician, known world-wide for her contribution and research in the field of neuromodulation and photobiomodulation therapies. She is also a co-founder of Recharge health.

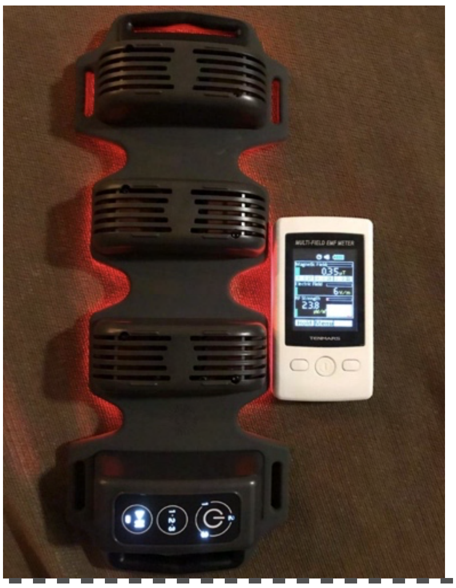
Arjen Helder is the inventor of FlexBeam. He is an experienced electronics engineer with extensive R&D background in optical technologies.

Summary



EMF – Electromagnetic Field Pollution

Unlike most LED devices on the market, FlexBeam provides photo-stimulation with minimal EMF (Electromagnetic Field) emissions. Additionally, it does not have Bluetooth capability, ensuring it is safe for use on the body.



References

[1] Karu TI, Afanas'eva NI. Cytochrome c oxidase as the primary photoacceptor upon laser exposure of cultured cells to visible and near IR-range light. Dokl Akad Nauk 1995; 342:693-95.

[2] Tuteja N, Chandra M, Tuteja R, Misra MK. Nitric Oxide as a Unique Bioactive Signaling Messenger in Physiology and Pathophysiology. J Biomed Biotechnol. 2004;2004(4):227-237. doi: 10.1155/S1110724304402034. PMID: 15467163; PMCID: PMC555773.

[3] Pollack G. The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor. Ebner & Sons; Seattle, WA, USA: 2013.

[4] Shapiro, M., Homma, K., Villarreal, S. et al. Infrared light excites cells by changing their electrical capacitance. Nat Commun 3, 736 (2012). https://doi.org/10.1038/ncomms1742

[5] de Freitas LF, Hamblin MR. Proposed Mechanisms of Photobiomodulation or Low-Level Light Therapy. IEEE J Sel Top Quantum Electron. 2016;22(3):7000417. doi:10.1109/JSTQE.2016.2561201
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5215870/

[6] Duffy JF, Czeisler CA. Effect of Light on Human Circadian Physiology. Sleep Med Clin. 2009;4(2):165-177. doi:10.1016/j.jsmc.2009.01.004

[7] Yeager RL, Oleske DA, Sanders RA, Watkins JB 3rd, Eells JT, Henshel DS. Melatonin as a principal component of red light therapy. Med Hypotheses. 2007;69(2):372-6. doi: 10.1016/j.mehy.2006.12.041. Epub 2007 Feb 23. PMID: 17321060.

[8] "Melatonin and the Optics of the Human Body", Scott Zimmerman Silas Inc., Basking Ridge, New Jersey, 07920, USA Russel.J. Reiter Department of Cell Systems and Anatomy, UT Health Science Center, San Antonio, Texas DOI: https://doi.org/10.32794/mr11250016

[9] Biphasic Dose Response in Low Level Light Therapy. 2009; 7(4): 358–383. Published online 2009 Sep 1. Hamblin PMCID: PMC2790317 PMID: 20011653

[1]0 H. T. Whelan, R. L. Smits, E. V. Buchman, N. T. Whelan, S. G. Turner, D. A. Margolis, V. Cevenini, H. Stinson, R. Ignatius, T. Martin, J. Cwiklinski A. F. Philippi, W. R. Graf, B Hodgson, L. Gould, M. Kane, G. Chen & J. Caviness (Dec 2001), Effect of NASA light-emitting diode irradiation on wound healing. Journal of Clinical Laser Medicine and Surgery, Vol. 19, Issue 6, pp305-14, accessed https://www.liebertpub.com/doi/10.1089/104454701753342758

[1]1 H. T. Whelan (Nov 2002), The use of NASA light-emitting diode near-infrared technology for biostimulation.

[1]2 M. E. de Abreu Chavez, A. Rodrigues Araujo, A. Costa Cruz Piancastelli & M. Pinotti (July-August 2014), Effects of low-power light therapy on wound healing: LASER x LED. Anais Brasileiros de Dermatologia, Vol. 89, Issue 4, pp. 616-623, DOI: 10.1590/abd1806-4841.20142519

[1]3 W. Kim & R. G. Calderhead (2011), Is Light-emitting diode phototherapy (LED-LLLT) really effective? Laser therapy, Vol 20. Issue 3, pp. 205-215, available at www.jstage.jst.jp/browse/islsm

[1]4 Heiskanen V, Hamblin MR. Photobiomodulation: lasers vs. light emitting diodes? Photochem Photobiol Sci. 2018 Aug 8;17(8):1003-1017. doi: 10.1039/c8pp90049c. Erratum in: Photochem Photobiol Sci. 2018 Oct 31;18(1):259-259. PMID: 30044464; PMCID: PMC6091542.