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ARTIFICIAL INTELLIGENCE

## 9.0 PHOTONIC ENERGY

# CONTENTS

9.0 PHOTONIC ENERGY.....	4
9.1 Does photonic energy have a future in the search for renewable energy sources .....	4
a) Solar Photovoltaics.....	4
b) Concentrated Solar Power (CSP):.....	4
c) Photonics for Energy Storage .....	4
d) Optics and Light Management.....	4
e) Emerging Photonic Technologies .....	4
9.2 Does photonic energy have a role to play in harvesting gravitational energy .....	4
9.3 Does photonic energy have a role to play in wireless power transmission .....	5
a) Light Generation.....	5
b) Conversion to Electrical Energy.....	5
c) Power Transfer .....	5
9.4 If photonic energy can be the source of supply to an inverter to connect to a generator to produce enough energy 24 hours per day, why is that not being used as the preferred renewable energy method .....	6
a) Intermittency.....	6
b) Energy Storage .....	6
c) Energy Demand and Scale.....	6
d) Regional Variation .....	6
9.5 Can you give me an example of work being done for novel photonic energy conversion mechanisms.....	6
a) Photon Upconversion via Triplet Fusion .....	6
b) Photon Upconversion via Intermediate Energy States.....	7
c) Photon Upconversion via Quantum Dots.....	7

- 9.6 Can photon upconversion improve the strength of microwave beams transmitted by satellites..... 7
- 9.7 How are photonic beams different to electromagnetic beams direct from the sun ..... 7
- 9.8 How are photonic beams different to electromagnetic beams direct from the sun ..... 8
- 9.9 Will photonics play a role in solar energy derived from the electromagnetic spectrum and beamed to earth..... 8
  - a) Photovoltaic Solar Cells:..... 8
  - b) Concentrated Solar Power (CSP):..... 8
  - c) Optical Fiber-based Solar Energy Transmission ..... 9
  - d) Spectral Conversion..... 9
  - e) Optical Coatings and Anti-Reflective Surfaces ..... 9
- 9.10 Can roof-top rectennas be built specifically for photonic energy transmission..... 9
  - a) Photonic Energy Capture ..... 9
  - b) Rectification ..... 9
  - c) Energy Conversion and Storage ..... 9

## 9.0 PHOTONIC ENERGY

### 9.1 Does photonic energy have a future in the search for renewable energy sources

#### ChatGPT Response

Yes, photonic energy has a significant future in the search for renewable energy sources. Photonics-based technologies play a crucial role in various renewable energy applications and have the potential to contribute to a sustainable and clean energy future. Here are a few reasons why photonic energy holds promise:

- a) **Solar Photovoltaics:** Solar photovoltaic (PV) systems, which directly convert sunlight into electricity, are the most well-known application of photonic energy. PV technology has been advancing rapidly, with improved efficiency, lower costs, and increased deployment. Photonic materials and devices, such as solar cells, help capture photons and convert them into electrical energy. Solar PV is already a major contributor to global renewable energy capacity and is expected to play a vital role in the transition to a low-carbon energy system.
- b) **Concentrated Solar Power (CSP):** Concentrated Solar Power systems use mirrors or lenses to concentrate sunlight onto a receiver, which generates thermal energy used for electricity production. Photonics is employed in the design of solar concentrators, efficient receivers, and the optimization of heat transfer. CSP has the advantage of thermal energy storage, enabling continuous power generation even when the sun is not shining, making it a valuable renewable energy technology.
- c) **Photonics for Energy Storage:** Photonics technologies also contribute to energy storage solutions, which are essential for the integration of intermittent renewable energy sources. Photonics-based materials and devices are used in advanced battery technologies, such as lithium-ion batteries, that store electrical energy generated from renewable sources. Energy storage technologies enable the efficient use and management of renewable energy, improving grid stability and reliability.
- d) **Optics and Light Management:** Photonics plays a critical role in optics and light management for renewable energy systems. It includes the design and optimization of materials, coatings, and structures to enhance light absorption, transmission, and control. These technologies are used in solar panels, optical fibers, and other components to improve energy capture, efficiency, and performance.
- e) **Emerging Photonic Technologies:** Ongoing research in photonic materials, nanophotonics, and quantum photonics holds promise for future breakthroughs in renewable energy. Advancements in materials and device engineering can lead to more efficient solar cells, novel photonic energy conversion mechanisms, and enhanced energy harvesting techniques.

Furthermore, photonics technologies are not limited to solar energy applications. They also find applications in other renewable energy sources such as wind energy, bioenergy, and hydroelectric power. For example, photonics can be used for wind turbine control systems, efficient lighting in greenhouses for bioenergy crops, and sensors for hydroelectric power generation.

Overall, photonic energy technologies contribute significantly to the development of renewable energy sources and their integration into the global energy mix. Ongoing research and technological advancements in photonics hold the potential to further enhance the efficiency, reliability, and scalability of renewable energy systems.

### 9.2 Does photonic energy have a role to play in harvesting gravitational energy

#### ChatGPT Response

As of my knowledge cutoff in September 2021, photonic energy has not been directly utilized for harvesting gravitational energy. Photonic energy primarily refers to the energy carried by photons, which

are particles of light. Gravitational energy, on the other hand, is associated with the potential energy stored in an object due to its position in a gravitational field.

While photonic energy is extensively used in various fields, such as solar energy conversion and optical communications, it is not directly applicable to harvesting gravitational energy. Harvesting gravitational energy typically involves utilizing mechanical or electromechanical methods, such as gravitational potential energy conversion to kinetic energy or the use of gravity-based systems like hydroelectric power plants.

That said, there may be indirect connections between photonic energy and gravitational energy in specific contexts. For instance, in the field of astrophysics, photons can be emitted or absorbed by celestial objects that possess gravitational energy, such as black holes or neutron stars. The interaction of photons with these objects can provide valuable insights into gravitational phenomena and astrophysical processes.

It's worth noting that scientific research and technological advancements continue to explore innovative ways to harvest and utilize different forms of energy, including gravitational energy. While photonic energy may not directly contribute to harvesting gravitational energy, interdisciplinary approaches and emerging technologies may uncover new possibilities in the future.

### 9.3 Does photonic energy have a role to play in wireless power transmission

#### ChatGPT Response

Yes, photonic energy can play a role in wireless power transmission, particularly in certain forms of wireless power transfer known as optical wireless power transmission or optical power beaming. Optical wireless power transmission involves using light, typically in the form of lasers, to transmit power wirelessly from a source to a receiver. Here's how photonic energy is involved:

- a) **Light Generation:** Photonic energy is used to generate the light source for power transmission. Lasers, which emit highly focused and coherent light, are commonly employed in optical wireless power transmission systems. The lasers convert electrical energy into photonic energy, which is then directed towards the receiver.
- b) **Conversion to Electrical Energy:** At the receiver end, photonic energy is converted back into electrical energy. Photovoltaic cells or photovoltaic receivers are used to capture the transmitted light and convert it into electrical power. These cells utilize the photovoltaic effect, where photons are absorbed by a semiconductor material, generating an electric current.
- c) **Power Transfer:** The captured electrical energy can then be utilized to power electronic devices or stored in batteries for later use. The photonic energy transmitted wirelessly is converted back into usable electrical energy without the need for physical connections between the power source and the receiver.

Optical wireless power transmission offers several potential advantages, such as increased safety, reduced electromagnetic interference, and the ability to transmit power over longer distances compared to traditional inductive or magnetic-based wireless power transfer systems.

It's important to note that while optical wireless power transmission shows promise, there are still challenges to overcome, such as efficiency losses over long distances and the need for precise alignment between the source and receiver. Research and development efforts are ongoing to optimize these systems and explore their practical applications in various domains, including space-based power transmission, charging of electric vehicles, and powering remote or inaccessible devices.

## 9.4 If photonic energy can be the source of supply to an inverter to connect to a generator to produce enough energy 24 hours per day, why is that not being used as the preferred renewable energy method

### ChatGPT Response

While photonic energy, such as solar energy, is indeed a widely used and preferred renewable energy source, there are a few reasons why it may not be the sole or preferred method for 24/7 energy production in all situations:

- a) **Intermittency:** Solar energy availability is dependent on daylight hours and weather conditions. During nighttime or cloudy periods, solar energy generation decreases or ceases altogether. This intermittency can pose challenges for providing a continuous and reliable energy supply without additional storage or backup systems.
- b) **Energy Storage:** To address the intermittency issue, energy storage systems, such as batteries, can be used to store excess solar energy generated during peak production periods for use during low or no production periods. However, large-scale and cost-effective energy storage solutions capable of supplying continuous power for extended periods are still developing and may not be suitable for all applications or economically feasible in every context.
- c) **Energy Demand and Scale:** Meeting the energy demands of an entire household or an industrial-scale operation solely through photonic energy may require a significant installation of solar panels, which can be constrained by factors like available space, cost, and system scalability. In some cases, combining solar energy with other renewable sources or conventional backup generators may be more practical or economical for 24/7 energy production.
- d) **Regional Variation:** Solar energy potential varies across different regions. Some areas may have less solar intensity or limited sunlight hours, making solar energy less viable as a standalone solution for continuous energy supply. In such cases, a mix of renewable energy sources, including solar, wind, hydroelectric, or geothermal, might be preferred to ensure a consistent power supply.

It's worth noting that the preferences and choices for renewable energy sources are influenced by a variety of factors, including local resources, energy policies, technological advancements, and economic considerations. The optimal renewable energy mix and system design will depend on specific circumstances, energy requirements, and the priorities of the given application or region.

## 9.5 Can you give me an example of work being done for novel photonic energy conversion mechanisms

### ChatGPT Response

One example of work being done for novel photonic energy conversion mechanisms is the field of "hot-carrier" or "photon upconversion" technologies. These technologies aim to enhance the efficiency of solar energy conversion by utilizing advanced photonics processes. Here's a brief overview of this research area:

Hot-carrier or photon upconversion technologies involve the conversion of low-energy photons into higher-energy photons through a multi-step process. The basic idea is to absorb two or more low-energy photons and combine their energies to generate a single, higher-energy photon. This higher-energy photon can then be more efficiently absorbed by a solar cell or other energy conversion device.

The concept of hot-carrier or photon upconversion is still in its early stages, but researchers are exploring various mechanisms and materials to achieve this process. Some potential approaches include:

- a) **Photon Upconversion via Triplet Fusion:** Triplet fusion involves the combination of two low-energy triplet excitons to create a higher-energy singlet exciton, which then emits a photon with higher

energy. This process can potentially enhance the efficiency of solar cells by harvesting low-energy photons that would typically be lost.

- b) **Photon Upconversion via Intermediate Energy States:** Another approach involves utilizing intermediate energy states or "virtual" energy levels in materials to facilitate the upconversion process. By harnessing these intermediate states, multiple low-energy photons can be sequentially absorbed and converted into a single higher-energy photon.
- c) **Photon Upconversion via Quantum Dots:** Quantum dots, which are nanoscale semiconductor particles, are being explored for their potential in photon upconversion. These tiny structures can exhibit unique optical properties, allowing for efficient absorption and emission of photons. Researchers are investigating how to harness quantum dots to achieve photon upconversion and improve energy conversion efficiency.

The development of novel photonic energy conversion mechanisms like hot-carrier and photon upconversion technologies is an active area of research. Researchers aim to overcome various technical challenges, including improving the efficiency and stability of the conversion processes, optimizing material properties, and finding suitable materials that can operate effectively across a wide range of wavelengths.

While these technologies are still in the experimental and early research stages, they hold the potential to significantly enhance the efficiency and performance of solar energy conversion systems. Continued advancements in photonic materials, device engineering, and understanding of fundamental processes will be crucial for the development and practical implementation of novel photonic energy conversion mechanisms in the future.

## 9.6 Can photon upconversion improve the strength of microwave beams transmitted by satellites

### ChatGPT Response

Photon upconversion is a process by which lower-energy photons are converted into higher-energy photons. It involves absorbing multiple low-energy photons and emitting a single higher-energy photon. While photon upconversion has been primarily studied and applied in the context of photonics and solar energy conversion, it is not typically used to improve the strength of microwave beams transmitted by satellites.

Microwave beams, as used in satellite communication, operate in the microwave frequency range, which is much lower in energy compared to visible light or higher-frequency electromagnetic radiation. Photon upconversion processes are more commonly employed in the visible or near-infrared spectral range.

To transmit microwave signals from satellites, specialized antennas and transmitters are used. These systems focus on maximizing the power and efficiency of microwave transmission, such as using high-gain antennas and optimizing the signal modulation and encoding techniques. Enhancing the strength of microwave beams is primarily achieved through engineering design improvements in the satellite communication systems rather than through photon upconversion.

Therefore, while photon upconversion is an interesting technology in the field of photonics and solar energy conversion, it is not directly applicable to improving the strength of microwave beams transmitted by satellites.

## 9.7 How are photonic beams different to electromagnetic beams direct from the sun

### ChatGPT Response

Photonic beams and electromagnetic beams are not fundamentally different; they are both forms of electromagnetic radiation. Electromagnetic radiation encompasses a wide range of wavelengths and frequencies, from radio waves to gamma rays, with visible light falling within a specific range.

Photonic beams typically refer to highly focused and directed beams of light that are generated using specific technologies like lasers. Lasers produce coherent and monochromatic light by amplifying and emitting photons in a controlled manner. These photonic beams can have unique properties, such as being narrow, intense, and capable of carrying large amounts of energy over long distances.

On the other hand, when we refer to electromagnetic beams directly from the sun, we are typically referring to the natural sunlight that reaches the Earth. Sunlight is a combination of various wavelengths of electromagnetic radiation, including ultraviolet (UV), visible light, and infrared (IR). It is not as focused or intense as a laser-generated photonic beam.

In summary, while both photonic beams and electromagnetic beams from the sun are forms of electromagnetic radiation, the term "photonic beams" generally refers to highly focused and controlled beams of light generated using technologies like lasers, whereas "electromagnetic beams from the sun" refers to the broader range of natural sunlight reaching the Earth.

## 9.8 How are photonic beams different to electromagnetic beams direct from the sun

### ChatGPT Response

As of my knowledge cutoff in September 2021, there is no specific term or technology known as "photonic beams" in the context of solar energy or electromagnetic radiation. However, I can provide information about photonic or electromagnetic beams from the sun.

The sun emits electromagnetic radiation across a broad spectrum, which includes visible light, ultraviolet (UV) radiation, and infrared (IR) radiation, among others. These different types of radiation can be categorized based on their wavelengths and frequencies.

Photonic or electromagnetic beams from the sun refer to the light and energy emitted by the sun in the form of electromagnetic waves. This energy travels through space in the form of photons. When sunlight reaches the Earth's atmosphere, it consists of a mixture of different wavelengths and frequencies, which together form white light. However, when this light passes through a prism or interacts with the atmosphere, it can be separated into its constituent colors, creating a visible spectrum.

On the other hand, the term "electromagnetic beams" is not commonly used and does not have a well-defined scientific meaning. It may be a misspelling or a term specific to a certain context that I'm not aware of.

In summary, electromagnetic beams direct from the sun refer to the diverse spectrum of electromagnetic radiation emitted by the sun, while "photonic beams" does not correspond to a known scientific term.

## 9.9 Will photonics play a role in solar energy derived from the electromagnetic spectrum and beamed to earth

### ChatGPT Response

Photonics can play a role in solar energy systems that involve the capture and transmission of solar energy derived from the electromagnetic spectrum. Here are a few ways photonics can be relevant in this context:

- a) **Photovoltaic Solar Cells:** Photovoltaic (PV) solar cells are devices that convert sunlight directly into electricity. Photonics plays a crucial role in PV solar cells by enabling the absorption and conversion of photons (particles of light) into an electric current. Photonics-based materials, such as semiconductors, are used to create the PV cells, which capture photons and release electrons, generating an electrical current.
- b) **Concentrated Solar Power (CSP):** CSP systems concentrate sunlight using mirrors or lenses onto a receiver to generate thermal energy, which is then converted into electricity. Photonics is employed



in the design and optimization of the mirrors and lenses used in these systems to efficiently focus and direct sunlight onto the receiver. Additionally, advanced photonics technologies can enhance the efficiency of heat transfer and thermal storage within CSP systems.

- c) **Optical Fiber-based Solar Energy Transmission:** Photonics-based technologies, including optical fibers, can be used to transmit solar energy from space-based or high-altitude solar panels to Earth. This concept, often referred to as space-based solar power or solar power satellites, involves capturing solar energy in space and transmitting it to Earth using lasers or microwaves. Photonics enables the efficient transmission of energy over long distances without significant losses.
- d) **Spectral Conversion:** Photonics can also be used for spectral conversion, where certain parts of the solar spectrum are converted to a different wavelength range more suitable for efficient energy conversion. For example, upconversion and downconversion techniques can convert low-energy photons into higher-energy photons that can be more efficiently absorbed by solar cells.
- e) **Optical Coatings and Anti-Reflective Surfaces:** Photonics plays a role in the development of optical coatings and anti-reflective surfaces used in solar panels. These coatings are designed to minimize reflection and maximize the absorption of sunlight, thereby increasing the overall efficiency of the solar panels.

It's important to note that while photonics technologies can enhance solar energy capture and transmission, the practical implementation of large-scale space-based solar power systems or other advanced concepts is still under development and faces significant technical and economic challenges. Nonetheless, photonics continues to be a crucial field of study and innovation in the renewable energy sector, aiming to improve the efficiency and effectiveness of solar energy conversion and utilization.

## 9.10 Can roof-top rectennas be built specifically for photonic energy transmission

### ChatGPT Response

Rectennas, which are devices that combine rectifying antennas, can indeed be built specifically for photonic energy transmission. However, it's important to note that the term "rectenna" is traditionally associated with the conversion of electromagnetic waves, such as radio waves or microwaves, into direct current (DC) electricity. Photonic energy transmission typically involves the transmission of photons (particles of light) rather than electromagnetic waves.

Nonetheless, the concept of rectifying antennas can be extended to capture and convert photonic energy into usable electrical energy. Here's how it could work:

- a) **Photonic Energy Capture:** Roof-top rectennas for photonic energy transmission would be designed to capture and collect photons from the incident light. This could involve the use of specialized materials, such as semiconductors or photovoltaic materials, that are capable of absorbing photons and generating an electrical current.
- b) **Rectification:** Once the photons are captured, the rectifying component of the rectenna would convert the alternating current (AC) produced by the photonic energy capture into DC electricity. Rectification involves the use of diodes or other rectifying devices that allow the flow of current in one direction.
- c) **Energy Conversion and Storage:** The DC electricity generated by the rectenna can be used directly for immediate energy consumption or stored in batteries or other energy storage systems for later use. This enables the utilization of photonic energy for various applications, such as powering appliances, charging electric vehicles, or feeding back into the electrical grid.

The design and optimization of photonic rectennas would require considerations such as the selection of appropriate photonic energy capture materials, the efficiency of rectification components, and the integration with energy conversion and storage systems.

It's worth noting that photonic energy transmission via rectennas is still an area of active research and development. Challenges such as the efficiency of photon capture, the design of high-performance rectification components, and the overall cost-effectiveness of the technology need to be addressed. However, advancements in photonic and energy conversion technologies continue to explore the potential of rectennas for capturing and converting photonic energy into usable electrical power.