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## Light for wireless data/energy transmission

In the last few years, the most common approach for wireless data transmission has been that based on the radiofrequency (RF) waves. For example, one of the most mature technology allowing the connection of electronic systems (e.g. laptops or smartphones) to a wireless LAN (WLAN) network is the WiFi one, which can operate in three center frequencies (2.4, 5 and 60 GHz). In the wireless data transmission there is a continuous trend to move the operating frequency towards higher frequencies in the electromagnetic spectrum. This trend is due to the need of maximizing the bit rate in the point-to-point and point-to-multipoint data transfer. In this scenario, a very innovative technology is under development, the light-fidelity (LiFi) one [1]. Since it enables the bi-directional multiuser communication, LiFi is conceptually equivalent to the WiFi but it uses visible light instead RF waves. The key devices of the transceiver utilized in the LiFi technology are the single photon avalanche diodes enabling the O/E transduction and the GaN micro-LEDs for the E/O transduction. Due to the widespread deployment of LED lighting, the existing lighting infrastructures can be easily used for the generation of the modulated light carrying data. The main advantages of LiFi with respect to WiFi are the avoidance of the radio frequency spectrum crunch (10,000 times more capacity), the enhanced energy-efficiency due to the combination of data communication and illumination, and complete elimination of health concerns due to the use of RF waves. The maximum bit rate in the LiFi network is around 10 Gbps. This value can be further enhanced up to 100 Gbps if laser diodes operating at visible wavelength instead of GaN micro-LEDs are utilized for the data transmission [2].

Light can be used for the wireless transmission of both data and energy. Wireless power transmission is a general concept referring to the transmission of electrical power without using the conventional conducting wires. Several experiments on the use of microwaves to transmit energy have been carried out since the beginning of the 20th century [3], but in the last few decades the advances in the laser technology has motivated an increasing research effort on the wireless energy transmission by laser beams. The basic concept of the photonic wireless energy transmission is quite simple. Electricity is converted into a laser beam that is pointed towards a photovoltaic cell re-converting the laser power into electrical energy. The key advantages of using laser beams instead of microwaves for wireless energy transmission are the possibility of transmitting energy over large distances, the absence of interference with the radio communication systems, and the potential compact size of both transmitter and receiver. Safety of the system is the main critical aspect of this technology. A block diagram of a system for wireless energy transmission by laser beams is shown in Fig. 1. The conversion of the electrical energy provided by the generator is obtained by a high-power laser diode. The laser beam is directed toward a photovoltaic array where the transduction of the optical power into electrical power takes place.

Fig. 1. Block diagram of a system for wireless energy transmission by laser beams [4].

Since the typical operating wavelength of the most efficient laser diodes is in the retinal hazard region (400–1400 nm), the systems for wireless power transmission by laser beams usually have to use appropriate techniques to mitigate the eye hazards and to protect animals from the optical beams carrying energy. One possible approach to make safe the laser power beaming is the inclusion within the wireless system of a sub-system detecting any object approaching the laser beam and switching off the laser transmitter when the beam is potentially dangerous. The use of laser sources operating outside the retinal hazard region could be a better solution to improve the safety level of the laser power beaming. Unfortunately, the lasers operating in the mid infrared, i.e. outside the retinal hazard region, typically exhibit low efficiency and are more expensive with respect to the laser diodes operating in the near infrared.

In the last few years, several experiments on the laser power beaming have been carried out. In particular, the wireless power delivery to an electric quadrotor helicopter in flight has been demonstrated [4]. In addition, the wireless power transmission over a distance of about 80 m from a Nd:YAG laser at 532 nm to a rover vehicle has also been experimented [5].

Wireless data and power transmission may become of particular importance for future HEP detectors in order to steer and control complex detector systems with reduced number of cables. Minimizing the amount of material in the region of the tracking detectors will reduce multiple scattering and nuclear interactions that degrade the tracking performance. We will also investigate the use of wireless techniques in detector readout in order to reach high data transfer rates, required by the highly granular detectors in HEP.

## References

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## Summary

Wireless data and power transmission may become of particular importance for future HEP detectors in order to steer and control complex detector systems with reduced number of cables. Minimizing the amount of material in the region of the tracking detectors will reduce multiple scattering and nuclear interactions that degrade the tracking performance. We will also investigate the use of wireless techniques in detector readout in order to reach high data transfer rates, required by the highly granular detectors in HEP.

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