European light research opens door for optical storage and computing

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The goal of replacing electronics with optics for processing data in computers is coming closer through cutting edge European research into the mysterious properties of “fast and slow” light. The long term aim is to boost processing speeds and data storage densities by several orders of magnitude and take the information technology industry into a new era, combining greatly improved performance with dramatically lower energy consumption.

The phenomenon of “fast and slow” light arises from the dispersion of electromagnetic waves when they interact with, and travel through, a physical medium such as a crystal. This can have the effect of slowing down the light pulses, or on occasions appearing to cause local acceleration. These speed variations have the potential for developing purely optical devices using just electromagnetic radiation, rather than electrical signals, to store and process information.

In the more immediate future, these properties will be used to enhance existing hybrid communication systems combining electronic and photonic (light-based) devices. But first more fundamental research is needed, and the current state of play along with a roadmap for future projects was discussed at a recent workshop organised by the European Science Foundation (ESF).

The project achieved its main objectives of reviewing the state of the art, highlighting possible applications, and gathering a dispersed European community of scientists, according to the workshop’s convenor

Marco Santagiustina. “There were two remarkable highlights: slow and fast light research has immense potential in applications like microwave and millimeter wave photonics, and secondly such applications can be targeted by making progress in a selected set of technologies,” said Santagiustina.

Light signals are already used for communication over fibre optic cables, but cannot yet be stored directly, or used for computation. This would require slowing down the light signals so that they can be buffered within a small area, and can be achieved by exploiting “fast and slow” light effects. Before the arrival of true photonic computing, there is the more immediate prospect of building optical interconnects for example in communication networks, which would reduce latency, the time taken for signals to travel from source to destination. Latency imposed by the communications network has become a significant problem in an age of globalisation where computers in different continents are cooperating in tasks that need to be executed very quickly in fractions of a second.

Another more immediate application of “fast and slow” light is likely to come from the ability in processing ultrawide band microwave signals, for radio communications, both for mobile telephony and wireless LANs. “Fast and slow” light can be harnessed to transmit radio frequencies directly over fibre, making it easier, cheaper, and more efficient to connect up base stations or wireless access points. “Radio over fiber is an existing application field destined to grow in the near future,” said Santagiustina. “This field will also represent a significant step forward for the photonic/electronic convergence. In that area the time-delay/phase-shift provided by slow and fast light devices can yield unprecedented functions.”

Some of these functions have not yet been conceived, but the fundamental point is that converging photonics with electronics reduces delays and increases the bandwidth available, cutting costs and boosting

communications capacity.

Source: European Science Foundation