Slow light

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EDITORIAL

Slow Light

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Research into slow light began theoretically in 1880 with the paper [1] of H A Lorentz, who is best known for his work on relativity and the speed of light. Experimental work started some 60 years later with the work of S L McCall and E L Hahn [2] who explored non-linear self-induced transparency in ruby. This field of research has burgeoned in the last 10 years, starting with the work of L Vestergaard Hau and coworkers on slow light via electromagnetically induced transparency in a Bose–Einstein condensate [3]. Many groups are now able to slow light down to a few metres per second or even stop the motion of light entirely [4]. Today, slow light – or more often 'slow and fast light' – has become its own vibrant field with a strongly increasing number of publications.

In broad scope, slow light research can be categorized in terms of the sort of physical mechanism used to slow down the light. One sort of slow light makes use of material dispersion. This dispersion can be the natural dispersion of the ordinary refractive index or can be the frequency dependence of some nonlinear optical process, such as electromagnetically induced transparency, coherent population oscillations, stimulated light scattering, or four-wave mixing processes. The second sort of slow light makes use of the wavelength dependence of artificially structured materials, such as photonic crystals, optical waveguides, and collections of microresonators. Material systems in which slow light has been observed include metal vapours, rare-earth-doped materials, Raman and Brillioun gain media, photonic crystals, microresonators and, more recently, metamaterials. A common feature of all of these schemes is the presence of a sharp single resonance or multiple resonances produced by an atomic transition, a resonance in a photonic structure, or in a nonlinear optical process.

Current applications of slow light include a series of attractive topics in optical information processing, such as optical data storage, optical memories, quantum information devices, and optical communication systems in which the use of slow light will allow all-optical processing with less wasted heat. To implement these applications, devices such as buffers, memories, interferometers and switches that utilize slow light need to be developed. Future challenges include the need for improved coupling of light into slow light modes, overcoming propagation losses, and mitigating the influence of large dispersion of the group velocity.

The collection of papers in this special issue of *Journal of Optics* features a broad spectrum of articles that highlight actual developments in many of the material types and schemes described above. It represents therefore an excellent up to date snapshot of the current state of the field of slow light research.

References

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