Feature issue on nonlinear optics provides insight into field's latest ideas

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A large number of researchers are working in the area of nonlinear optics, which is the study of all effects that can be described as multi-photon interactions in various materials systems, including cases where the frequency of one or more photons tends to zero. Motivated by the needs of these researchers, meetings have sprung up over the past few years under the name "Foundations of Nonlinear Optics." The two most recent of these meetings took place at Lehigh University in 2015, and at Tufts University in 2016, and the next one will take place at the University of Bahamas.

Now, a special feature of *The Journal of the Optical Society of America B* has been published with contributions from several of the participants in these meetings, as well as others. The issue is called Nonlinear optics near the fundamental limit and it contains articles ranging from the fundamental, first principles analysis of the nonlinear response and its origins, to experimental work.

According to the issue's introduction: "This feature issue is dedicated to works on both second-order nonlinear optics (three-photon interactions) and third-order nonlinear optics (four-photon interactions) that focus on understanding the fundamental mechanisms of the nonlinear optical response when the nonlinearity is large and approaches the fundamental quantum limit—a regime required by applications and characterized by interesting physics."

Co-editor Biaggio, a professor in Lehigh's Department of Physics says:

"The whole feature issue is about looking for new ways to understand and optimize the ability of certain materials to mediate light-light interaction. Examples are two photons of the same frequency combining to create one at twice the frequency—known as second harmonic generation—or three photons combining to produce a fourth one—which could potentially lead to things like optical transistors."

An article from Biaggio's research group—titled "Optimum conjugation length in donor-acceptor molecules for third-order nonlinear optics"—is also included in the feature issue. The study builds on the team's previous research that demonstrated record-high performance for individual molecules and developed a new way to use those molecules to fabricate high quality solid state materials—materials that have then been used to add nonlinear optical functionality to standard integrated optics circuitry.

Biaggio says that studying how the nonlinear optical efficiency is maintained when making the molecules larger is important because increasing molecular size is one of the ways used to increase the strength of the effects that lead to multi-photon interactions. The team had previously noted that by adding special groups to a small molecule—called donor and acceptor groups—it is possible to keep the molecule close to those record-high values in efficiency. But, he says, this can only work when the molecules do not get too large.

"This article provides the first look into how making organic molecules longer—by adding more carbon atoms to a chain of carbon atoms—influences their ability to mediate multi-photon interactions for all-optical switching, and how that ability depends on the wavelength of the photons," says Biaggio.

He adds: "In this study, we have finally determined experimentally how far one can go in making the molecule larger while still enjoying the benefits of donor-acceptor substitution."

More information: Timothy J. Atherton et al, Nonlinear optics near the fundamental limit: introduction, *Journal of the Optical Society of America B* (2016). DOI: 10.1364/JOSAB.33.00NOF1

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