Seminar announcement

Tuesday, July 11, 2023
2 pm
WSI, Seminar room S 101

“Why do the refractive indexes of different materials differ so little and are also so difficult to change?”

For too long the functionality of optical devices and systems has been severely restricted by the very limited range of refractive indices at the disposal of designers. These limitations become especially constricting in the currently most active areas of optics – integrated photonics, photonic crystals, metamaterials and metasurfaces. A simple increase of the value of refractive index by 50% can result in disproportionally large improvement in performance (i.e. smaller size, less cross-talk, higher resolution, and so on, depending on application). With that in mind, I explore what are the fundamental limits that limit the scope of refractive indices as a function of wavelength, explain why higher index materials have not yet materialized and point out a few tentative directions for the search of these elusive materials, be they natural or artificial.

In the second part of the talk, I investigate a closely related issue: changing refractive index to achieve effective modulation. There exist many methods of index modulation, starting with Pockels and Kerr electro-optic effects, acousto-optic and opto-mechanical effect, optical nonlinearities, thermal, carrier injection/depletion, etc. In my talk I will try to provide a comprehensive analysis that will show that independent of the modulation technique, one must supply and maintain (but not necessarily dissipate) anywhere between few times 103 and 105 J/cm3 of energy in order to achieve relative index change on the order of 50-100% (with energy requirements increasing in sync with the increase of operating frequency). The general conclusion is that unless radically new material systems are developed, the improvement of the performance of existing modulation techniques will have evolutionary rather than revolutionary character with no order of magnitude improvement in sight. I will try to argue for using collective effects and fast phase transitions to achieve future breakthroughs.

Speaker’s biography: Jacob B. Khurgin had graduated with MS in Optics from the Institute of Fine Mechanics and Optics (ITMO) in St Petersburg, Russia in 1979. In 1980 he had emigrated to US, and, rather surprisingly, got a job with Philips Laboratories in Briarcliff Manor, NY. There for 8 years he worked with on miniature solid lasers, II-VI semiconductor lasers, various display and lighting fixtures, and small appliances like coffeemakers. Simultaneously, he was pursuing his graduate studies at Polytechnic Institute of NY where he had received PhD in Electro-physics in Jan. 1987. In Jan. 1988 he joined the ECE department of Johns Hopkins University, where he is currently a professor. His research topics over the years comprise an eclectic mixture of diverse subjects, such as optics of semiconductor nanostructures, nonlinear optical devices, semiconductor lasers, optical communications, plasmoncis, metamaterials, laser refrigeration, microwave photonics, opto-mechanics, and more or less fundamental condensed matter physics. He is a fellow of OSA and APS.

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