Graduate and postdoc opportunities in a newly established research group

I am a new faculty member at the Technion and will be arriving in the summer of 2017. I am looking for a few excellent graduate students (MSc or PhD) and one postdoc, who will come to MIT and be trained by me in the existing facilities there, so they will already be trained when our new lab becomes operational.

The research involves both theory and experiments, but is flexible enough to be focused on either full-time experimental work, or purely advanced theory.

We aim to devise new ways of exploiting the wave nature of light and matter to control and facilitate light-matter interactions in complex and novel nano-structures.

Do you have?

- Excellent analytical abilities and a love of mathematics
- … and/or a hands-on approach to experiments, and eager to build a challenging new experimental setup that does not exist anywhere else in Israel
- … and/or interest in solving challenging problems (in physics, electrical engineering, math, or material science)

Then come work with us!

Relevant also as part of the Technion's ***nano*** or ***energy*** graduate programs.

Optional: start early and come work at MIT during this academic year.

Research highlights:

- Using graphene plasmons to engineer compact sources of x-ray [Nature Photonics]
- Enabling forbidden selection rules in atomic transitions [Science]
- A complete analytic quantum theory describing the emergence of shock waves of light, i.e., Cherenkov radiation [PRX]; enabling efficient conversion of electrical energy to light in graphene [Nature Communications]
- Novel dynamics of light in photonic crystals [Optics Express, Nature]
- Fun hard-code theory on mind-boggling physics: quantum particles that accelerate with no external force and even exhibit time dilation and length contraction [Nature Physics]; featured on the journal cover (also see commentary and article about it).
- Discovering beams of light that bend themselves in free space along steep curves: new analytic solutions of Maxwell equations [PRL]
- Solitonets: stochastic recurrent dynamics in complex networks [PRL]

Assembling the first 4D electron microscope in Israel (one of a few in the world): spatial+temporal resolution enhanced by 10 orders of magnitude!

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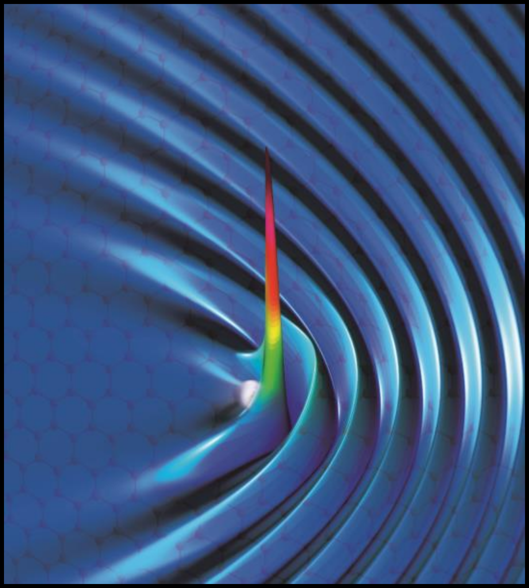
General research interests

A central challenge in several scientific disciplines is the invention of novel concepts for radiation generation in spectral ranges beyond those currently accessible by existing technologies, particularly in terahertz, hard-ultraviolet, and x-ray.

Current technology allows us to generate and detect electromagnetic signals, in wide spectral ranges from radio waves and microwaves, through infrared and visible light, to x-ray radiation. Around each of these spectral ranges entire industries have emerged: radio communication, cellular phones, optical communication, display screens and lighting; medical imaging (respectively). Each of these innovations have been made possible by groundbreaking discoveries in fundamental physics.

Nonetheless, given the unparalleled importance of these spectral bands, it is astounding that entire sectors of the electromagnetic spectrum remain practically out of technological and scientific reach. Chief among these sectors are the terahertz, hard-UV, and soft x-ray ranges. Unlocking the exceptional scientific and industrial potential of these spectral ranges requires non-trivial progress in several fundamental areas of physics and material science.



By using light trapped on the surface of graphene to “wiggle” free electrons, we have proposed a new method for generating X-rays.

In this image, the color and height represent the intensity of the radiation (blue is the lowest intensity and red is the highest) at a moment in time just after an electron (grey sphere) generates a pulse. The tunability and compactness of the scheme make it attractive as a table-top or even on-chip source of high-frequency radiation for applications in medicine, engineering, and the natural sciences.

Read more:

Our Nature Photonic paper and commentary

News coverage

The development and pursuit of novel concepts for sources of radiation is closely interlinked with several fundamental and long-standing problems in physics and material science. In particular, several central theoretical questions have remained unanswered and actively debated for decades. In addition to experimental efforts, our research group centers on several of these open theoretical problems. Several recent breakthroughs in physics and material science suggest novel platforms and concepts from which these questions may be explored.

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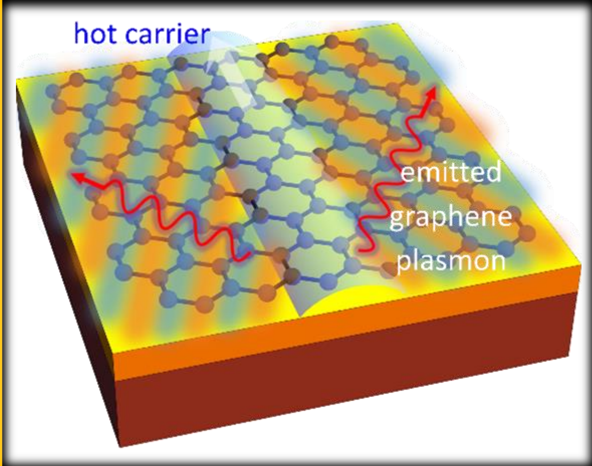
The lab: 4D electron microscopy - super resolution in space and time

Following the visionary work of Nobel Laureate Ahmed Zewail, we are building a new lab that combines an electron microscope with a femtosecond pulsed laser. This would be the first system of its kind in Israel, and one of just a few in the entire world. Will involve research abroad to learn the state-of-the-art techniques at MIT and EPFL.

The system will provide a range of unprecedented capabilities in physics and materials research enabled by having exceptional spatial and temporal resolution simultaneously accessible (10 orders of magnitude better than conventional microscopes!). It will also enable us to demonstrate new proof-of-concept concepts for compact x-ray sources.

Graphene can trap light in two dimensions and slow it down by more than two orders of magnitude. This effect poses a unique opportunity: for the first time, the speed of light in a conductor can be made comparable to the speed of charge carriers responsible for the conduction of electrical current in it.



Our recent theoretical work shows that this can lead to an entirely new way of generating light. The interaction between the electrical current and the trapped light in graphene (called graphene plasmons) offers a highly efficient, tunable, and ultrafast energy conversion mechanism from electrical current to light.

This conversion is made possible because the electronic speed exceeds a threshold given by the light speed in graphene, breaking the “light barrier.” This mechanism is an analogue of an object, e.g., a jet plane, breaking the sound barrier, leading to a shock wave known as a sonic boom. In the case of graphene, this leads to the emission of a shock wave of light trapped in two dimensions.

Read more:

Our paper in Nature Communications and news coverage.

On the more fundamental side: shock waves of light, also called "Cherenkov radiation", is a discovery from 1934 (Nobel Prize 1958) that has received – and continues to receive – tremendous attention in the past 80 years. Nevertheless, we have found new effects hiding there, like the entanglement between electrons and photons.

Looking forward

We have introduced new theoretical concepts that we would apply to attack some of the most famous open problems in physics. One such example is the problem of radiation reaction; a topic Feynman wrestled with during his PhD work (see e.g., Feynman’s Nobel acceptance speech).

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