Tanya Domi: Hi, this is Tanya Domi. Welcome to The Thought Project recorded at the Graduate Center of the City University of New York, fostering groundbreaking research and scholarship in the arts, social sciences, and sciences. In this space, we talk with faculty and doctoral students about the big thinking and big ideas generating cutting edge research, informing new Yorkers and the world.

Tanya Domi: Professor Andrea Alu is the founding director of the photonics initiative at the Advanced Science Research Center at the Graduate Center CUNY. He is also the Albert Einstein professor of physics at the Graduate Center and a professor of electrical engineering at City College. Alu has received numerous awards and recognition for his breakthroughs in invisibility cloaking, a technology that makes objects undetectable to monitoring signals and also sound cloaking.

Tanya Domi: Alu's leapfrog discoveries are powered by his work to create novel methods for manipulating light waves and sound waves. An electrical engineer by training, Alu received his PhD from the University of Roma Tre in Rome and he conducted his postdoctoral research at the University of Pennsylvania. He holds more than a dozen patents and patent applications and has coauthored more than 500 frequently cited contributions to scientific literature. Welcome to The Thought Project, Dr. Alu.

Dr. Alu: Thanks for having me.

Tanya Domi: As I understand it, and this isn't my specialty, but photonics involves studying the behavior of light waves and how we can manipulate and control them. Can you help us understand why this field of study is so critical to advancing multiple areas of science and technology?

Dr. Alu: Yeah. Light and in general, electromagnetic waves are everywhere around us. We're used to rely on them for the most common activities in our daily life. For instance, we see our objects around us based on light, and mankind has been trying to control and manipulate the light since the really early stages of civilization. Think for example of mirrors or lenses that reflect or focus light.

Dr. Alu: Thanks to really enormous recent progress in nanotechnology, we have become very sophisticated in controlling light waves and the science of photonics has emerged. Photonics, the word comes from photons that are the quanta of light, and the study is how to use these light bits to improve science and technology. In recent years we have understood that controlling light enables really exciting advances in many areas of modern technology.

Dr. Alu: For instance, a simple example is the enormous flow of photons that the sun sends our way everyday with sunlight. Creating the most efficient technology that harvests a portion of this energy opens really important opportunities for green energy, and addresses current societal challenges with the global warming and carbon-based energy production.

Tanya Domi: Okay, well hasn't one of the things that you've been working on is like cloaking, like stealth technology, cloaking sound and images, right? Like for example, whenever I hear cloaking I think of Star Trek and when they say, "Cloak up," and they block an object so that you can't see it coming at you.

Dr. Alu: Yeah, that fits within this real world applications. Essentially our eyes see objects by detecting the photons that bounce off the surface of the object. So one thing we realized is that if we design properly engineered materials that can be wrapped around an object, we can drastically reduce the way in which these photons are scattered around. And if you are able to completely suppress the scattering, you get actually an ideally transparent object. So it becomes invisible or undetectable by sensors placed around the object.

Tanya Domi: It's pretty remarkable. So where does the study of sound waves, actually what we're just talking about, fit into our traditional understanding of photonic science?

Dr. Alu: Sound of course is a different type of wave. The quanta of sound are actually phonons, not photons. But our group has been real interested in these interdisciplinary activities going beyond the conventional optics applications. And it's quite remarkable that the way in which sound travels follows very similar laws and rules as light. So what we've been quite successful at is to translate some of the more familiar concepts in optics into acoustics and sound. And the particular interesting area is the era of optomechanical, in which actually light and sound are very much coupled together and interact with each other. The idea is to build nanostructures for which when light bounces off the surface of the structure, it applies a very tiny pressure that is sufficient to establish some acoustic vibrations.

Tanya Domi: Can you give us an example of what you're talking about, like in concrete terms? Is there an example that you can give us?

Dr. Alu: So we engineer structures at a very small scale, at a nanometer scale in a way that when light bounces off these objects, it starts some vibrations. These vibrations are essentially sound, and what's interesting is that these vibrations change the way in which the objects interact with the light itself. So now light and sound becomes very much interleaved together.

Tanya Domi: Interconnected.

Dr. Alu: Yes, quite an unusual applications in leveraging the strong connections between the two.

Tanya Domi: Last year your lab received a five year 7.5 million dollar grant from MIRI where you're working with the Air Force to create materials that will leapfrog our ability to control how light travels. How would the success of this work change the technology that we use in our everyday lives?

Dr. Alu: Yeah. This is another very multidisciplinary project that we started the last year, and in this project the goal is to show that suitable variations in time or material can change the way in which usually materials interact with electromagnetic waves in light. One of the major objectives is to actually break the symmetry with which waves travel in common materials. If I try to send a beam of light from point A to B, equations governing this propagation tell me that light should also be able to go back from B to A with the same efficiency. But what we proved is that using time variations in the materials involved in this wave propagation, the symmetry can be largely broken. So you can send a beam of light down a certain path, but you are certain that the reflections do not come back.

Tanya Domi: So in the Air Force, are we talking about weapons? Are we talking about-

Dr. Alu: No, no. These are basic research efforts.

Tanya Domi: Basic research.

Dr. Alu: There is no applied... Actually the Air Force and in general the Department of Defense is very generous in sponsoring groundbreaking advances for technology. They have been behind the development of the internet for instance.

Tanya Domi: Sure. Of course, of course.

Dr. Alu: In this specific example, what we are looking at are improved radar and laser technologies.

Tanya Domi: I see.

Dr. Alu: And also cell phone and wireless communication and technologies largely benefit from breaking the symmetry.

Tanya Domi: I see. Okay. That makes sense. So this October 30th, the ASRC is celebrating its fifth anniversary. What can researchers and students at CUNY and beyond CUNY expect from the photonics initiative as the ASRC moves into this new era of its existence and research?

Dr. Alu: Yeah, we're very excited about this anniversary upcoming and our initiative at ASRC has been developing exciting new science and technology. That's the final goal, really addressing the grand challenges in modern society, including NFG communications, sensing, computing. We put together a really impressive team of scientists and also striking range of facilities to facilitate our research, and we really look forward to working with CUNY, the other initiatives at ASRC to push forward really the ultimate grand challenges of our society and technology.

Tanya Domi: That's great. I want to thank you for coming today and talking about what's going on in the photonics initiative. We want to have you back when you indeed achieve some of these leapfrogs and novel discoveries.

Tanya Domi: Thanks for tuning in to The Thought Project, and thanks to today's guest, Professor Andrea Alu at the Advanced Science Research Center of The Graduate Center CUNY. The Thought Project is brought to you with production, engineering, and technical assistance by Kevin Wolfe of CUNY TV. I'm Tanya Domi. Tune in next week.