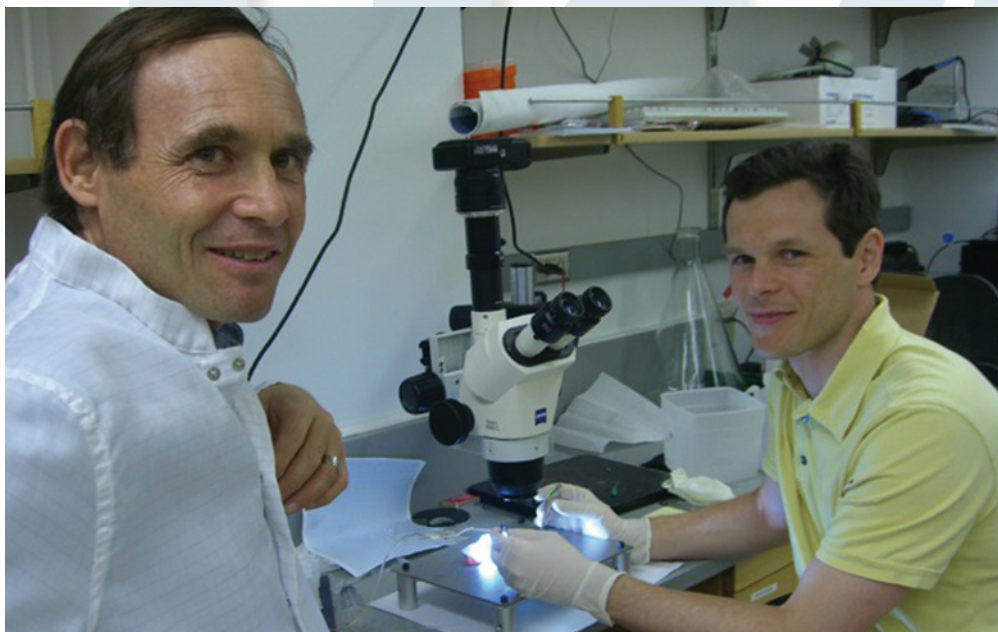


Dr Peter Siegel

Caltech



DR PETER H. SIEGEL is Faculty Associate in Electrical Engineering, Senior Scientist in Biology at Caltech, and Senior Research Scientist and Technical Group Supervisor for Submillimeter Wave Advanced Technology at the Jet Propulsion Laboratory (JPL) in Pasadena, CA. He has been working in the areas of millimetre- and submillimetre-wave technology and applications for 35 years. At JPL, he develops terahertz technology for NASA's near- and long-term space science missions, and at Caltech, Dr. Siegel is involved in new biological and medical applications of terahertz radiation.

Q. What inspired you to become a researcher?

A. When I grew up in the US in the 1960s, science was heralded as the 'future of mankind'. I was fascinated by science and science fiction. This was the time of the space programme, Sputnik, and Kennedy. I always had a strong interest in astronomy and I pursued it as a hobby from the time I was 15 years old. When I went to college, I was attracted by an enthusiastic and wonderful Astronomy Department Chair, Dr. Anthony Aveni (best known for his work in Mexican Astroarchaeology), and the newly established Colgate Observatory with its unusual 16 inch Ritchey Chretien telescope.

Q. How did you get started in your academic career?

A. When it was time for graduate studies, I got a job in the summer of my junior year at the NASA Goddard Institute for Space Studies (GISS), working for astronomer Dr. Patrick Thaddeus (now at the Harvard Smithsonian) on millimetre-wave receiver development under Dr. Anthony Kerr (now at the National Radio Astronomy Observatory – NRAO – in Charlottesville, VA). I decided to stay in my GISS job and try physics at Columbia. By 1978, I had decided to do a PhD in microwave engineering. With Dr. Kerr as an advisor, I worked on millimetre-wave receivers and became hooked. I was recruited to JPL in 1987 by Dr. Margaret Frerking, an early pioneer in terahertz astronomy, where I was also able to branch out into applications in Earth Science with Dr. Joe Waters.

Q. When did you start working in the terahertz field?

A. My first work in the terahertz field (known as the submillimetre-wave bands back then) began in 1983 with my NRC post-doctoral appointment at GISS. I worked on submillimetre-wave mixer development at 350 and 700 GHz, and this involved concepts for planar antennas and down-converter circuits that could eventually be used in imaging arrays for spectral line observations in radio astronomy. I continued this work at NRAO and later at JPL.

Q. Tell us about your current research activities.

A. At JPL, I became very involved in two Earth Science programs for stratospheric chemistry because of the broad impact these missions had. As funding for THz space science began to decline and new emphasis was being placed on biological advances, I was also lucky enough to get a retraining grant from the National Institutes of Health in 2002, and a staff position with Professor Scott Fraser at Caltech, that allowed me to start learning some of the tools necessary to apply terahertz in the bio-world. Most recently, I have been working with Dr. Victor Pikov, a neurophysiologist at the Huntingdon Medical Research Institutes in Pasadena, on the practical applications of terahertz in the biomedical world. Most of these applications currently fall in the millimetre-wave regime (owing to the increased penetration depths). Our most interesting work is on stimulation of neurons with very low levels of millimetre-wave power (1000 x below the maximum permissible exposure level), which has potential applications in neurophysiology and perhaps even generic cell membrane depolarisation (drug delivery).

Q. What you like best about working on terahertz.

A. The reason that I love the terahertz field is because it combines so many skills from different disciplines, and every step forward is a big challenge. For me, this is what science is all about. The community is small and highly motivated, very international and it feels like one big family. It's really a dream come true.

Q. Within your area, what are the key challenges?

A. Prosaically, the key challenge is the funding. Raising funding occupies 80% of my time! From a

Dr Peter Siegel (left) and Victor Pikov (right) in the Caltech Beckman Biology Building Leech laboratory learning how to prepare a specimen (extract a ganglion) for millimetre-wave stimulation under the guidance of Caltech Broad Scholar Dr. Daniel Wegenaar

scientific point-of-view, a key challenge is getting biological systems to the point where we can do comprehensive, repeatable, and highly quantitative measurements. It's hard to measure electromagnetic absorption at the cellular scale. We would love to have a technique and a bio-compatible sensor that could separate out thermal heating and direct field coupling to cells on a micron scale.

Q. It has often been said that 'terahertz is a solution looking for a problem' – do you agree?

A. Certainly not! We have a fantastic 'killer' application, and it's critical to all of us. It's environmental science – pollution monitoring, ozone distribution, global warming, radiation balance etc. Terahertz spectroscopy played a great role in helping our understanding of stratospheric ozone chemistry and global water distribution. Terahertz space science has thrived over the last two decades and with the recent launch and deployment of the Herschel Space Telescope, and there have been more than a dozen astrophysics space science missions over the past two decades that have focused on this frequency regime. The field of Earth Science alone is more than enough to justify the whole of our terahertz activity internationally.

Q. What do you see as the prospects for exploiting terahertz technology in space, and the key barriers?

A. I think terahertz time-domain spectroscopy is one new technique in this field that has a role to play in space, but it typically takes 15–20 years for any new technology to enter the space science market. We will continue to propose, and perhaps one day be awarded, a terahertz planetary or space science mission – hopefully before my career comes to an end!

Q. What one key thing would transform the terahertz field?

A. If I wanted to be cynical, I would answer cost. Terahertz components and instrumentation are far too costly to be used in anything but the most unique applications, where no other methods exist or compete. It is hard to see how terahertz can continue to grow as a field without dramatic breakthroughs in cheap, easy-to-use detectors, sources, and beam guiding structures. If I were to make a prediction, I would say that terahertz MMIC technology has the best chance of opening up the field to activities in areas of digital and analogue IC circuitry, communications and imaging.

Q. What is the potential for terahertz that you find the most exciting?

A. Terahertz is a niche field right now and there is very limited formal training available. What I love about the field is that it is wide open. No one can tell you what technique is the best for solving a particular problem or what new approach might completely dominate in the future. It's a great field for people who want to strike off in their own direction. My advice is take a chance on a new approach, stick to it until you are convinced it won't work, and then move on to another method. Eventually you'll get there, and you will have some surprises along the way!