TT 19: Symposium "Terahertz Detectors"

Time: Wednesday 14:00–18:00 Location: H20

Invited Talk TT 19.1 Wed 14:00 H20

Superconducting detectors and mixers for submillimeter astrophysics — •Jonas Zmuidzinas — California Institute of Technology, 320-47, Pasadena, California 91125, USA

Fueled by advances in technology and instrumentation, astrophysics at submillimeter wavelengths has been transformed over the past three decades from a small effort at the fringes of the science into one of its major disciplines. Early developments focused on the superconducting tunnel junction (SIS) mixer, which was invented in the late 1970's and motivated the international ALMA project now being constructed in Atacama, Chile. A second superconducting mixer technology, the hot electron bolometer (HEB) mixer, rose to prominence during the 1990's and allows access to the THz frequencies beyond the reach of SIS devices; both SIS and HEB mixers are used in the HIFI instrument for ESA's 3.5 meter Herschel Space Observatory. In parallel, a technological revolution in submillimeter imaging detector arrays is underway, highlighted by the UK's SCUBA 2 project which relies on superconducting devices for its 10,000 pixel bolometer arrays (TES) and multiplexing electronics (SQUIDs). The TES/SQUID technology is being followed by a new generation of devices, such as the microwave kinetic inductance detector (MKID), and collectively these advances motivate the construction of a large (25m) single-dish telescope in Atacama, CCAT. This review will discuss the history and current status of the field, the interrelationsip between technological and astronomical advances, and the connections to other areas of research.

Invited Talk TT 19.2 Wed 14:40 H20

Superconducting detectors for low-background far infrared space astronomy — •Philip Mauskopf — School of Physics and Astronomy, Cardiff University, Queen's Buildings, Cardiff CF 24 3AA, UK

The next generation of far infrared astronomy satellites will have cooled telescopes to reduce the thermal background to very low levels. In order to take advantage of the low background, arrays of sensitive detectors will be needed, with NEPs of 10^{-19} W/$\sqrt{\text{Hz}}$ or less - more than an order of magnitude better than can be achieved using conventional photoconductive detectors. We will review the technical requirements for such arrays and report on the development of transition edge superconducting detectors and kinetic inductance detectors suitable for use with an imaging spectrometer instrument in the 40-200 micron region.

TT 19.3 Wed 15:20 H20

Terahertz detectors using hot-electrons in superconducting films — •Alexei Semenov — DLR Institute of Planetary Research, Berlin, Germany

Recently the terahertz gap has been recognized as a prospective spectral range for radioiastronomy as well as for material and security studies. Implementation of terahertz technology in these fields requires further improvement of instruments and their major subcomponents. Physical phenomena associated with the local and homogeneous non-equilibrium electron sates in thin superconducting films offer numerous possibilities for the development of terahertz and infrared detectors. Depending on the nature of the resistive state and the operation regime, a variety of detector can be realized. They are e.g. direct bolometric or kinetic inductance detectors, heterodyne mixers or photon counters. Operation principles and physical limitations of these devices will be discussed. Two examples of the detector development made in cooperation between the German Aerospace Center, the University of Karlsruhe and PTB, Berlin will be presented. The energy resolving single-photon detector with an almost fundamentally limited energy resolution of 0.6 eV at 6.5 K for photons with wavelengths from 400 nm to 2500 nm and the heterodyne mixer quasioptically coupled to radiation in the frequency range from 0.8 THz to 5 THz and providing a noise temperature of less then ten times the quantum limit. The mixers will be implemented in the terahertz radar for security screening (TERASEC) and in the heterodyne receiver of the stratospheric observatory SOFIA.

TT 19.4 Wed 15:50 H20

SIS and HEB Devices for THz Frequency Mixer Applications — •Karl-Friedrich Schuster — IRAM, 300 Rue de la Piscine, 38406 St Martin d'Heres, France

Heterodyne mixers using superconducting tunnel (SIS) junctions or hot electron bolometers (HEB) are among the most successfully used superconducting devices and play a key role in ongoing and future projects for space and ground based astronomy in the THz range. Introduced already 20 years ago SIS junctions for frequency mixing still undergo important developments which prepare the ground for optimized device performance and functionality. While SIS mixers are used in the domain up to 1 THz, mixers using hot electron bolometers are particularly well suited for the higher THz range. I will present a short overview on the current development goals for both mixer device types and then discuss the technological challenges within the fabrication process and the underlying physical questions.

10 min. break

TT 19.5 Wed 16:30 H20

Terahertz Bolometer Arrays for APEX — •Ernst Kreysa — MPIfR, Bonn, D

The Atacama Pathfinder Experiment (APEX) is a new terahertz telescope in the southern hemisphere. It is situated at an altitude of 5100 m, on Llano de Chajnantor in the Chilean Andes, where the atmospheric transmission is superb during a significant fraction of the year. The site is so dry that observations in the atmospheric window at 1.5 THz are feasible. With a diameter of 12 m and a surface of 18 micron rms, APEX is presently the most powerful terahertz telescope. At the Cassegrain focus, its field of view extends to about half a degree, making it very suitable for large scale mapping. The challenge for large terahertz bolometer arrays at APEX is that the Cassegrain cabin is so small. It also has only limited access and will tilt in elevation during observations. Sub-Kelvin cryogenic coolers or cryostats have to work under these conditions reliably and remotely. A first generation instrument, the large bolometer camera (LABOCA-1) with 295 bolometers for 345 GHz is being commissioned. While LABOCA-1 is still based on semiconductor thermistors, there can be no doubt that for really large arrays, superconducting bolometers with multiplexed SQUID readout are required. This new technology is being demonstrated with a small array of 40 bolometers for 0.85 THz. Results of these developments, carried out in cooperation between the Max-Planck-Institute for Radioastronomy (MPIfR) in Bonn and the Institute for Physical High Technology (IPHT) in Jena, will be presented.

TT 19.6 Wed 17:00 H20

FIR Detectors for Herschel and SOFIA — •Albrecht Poglitsch[1], P. Agnese[2], L. Barl[1], N. Billot[3], O. Boulade[3], L. Duband[4], U. Groezinger[5], R. Hoenle[1], and P. Merken[6] — [1]MPE, Garching, Germany — [2]LETI, Grenoble, France — [3]CEA, Saclay, France — [4]CEA, Grenoble, France — [5]MPIA, Heidelberg, Germany — [6]IMEC, Leuven, Belgium

We report the development of new, large format detectors for the 50 - 200 micron wavelength range for use in cameras and spectrometers.

The lowest detector noise, needed for background-noise limted spectroscopy, is achieved with Ge:Ga photoconductor arrays. These arrays are based on individual Ge:Ga detectors contained in integrating cavities. In order to detect light at wavelengths >120 microns, uniaxial stress is applied to each detector crystal. In combination with their cryogenic readout circuits, these detectors reach effective quantum efficiencies of >30% under representative background conditions, or NEPs down into the 10ˆ-18 W/sqrt(Hz) range.

For the higher background experienced in photometry we have developed 3-sides buttable bolometer arrays. They represent the first monolithic filled arrays of bolometers with a cold multiplexed readout. They have been optimised for both, high FIR absorption efficiency and minimum cross section to cosmic rays for operation in a space environment. The bolometers, working at a temperature of 300mK with a dedicated 3He cooler, have an NEP of ˜10ˆ-16 W/sqrt(Hz) and a post-detection bandwidth of 4 to 5 Hz.

TT 19.7 Wed 17:30 H20

A superconducting Terahertz imager — •Torsten May[1], Viatcheslav Zakosarenko[1], Solveig Anders[1], Hans-Georg Meyer[1], Günther Thorwirth[2], Ernst Kreysa[3], and Nikhil Jethava[3] — [1]IPHT Jena e.V., Albert-Einstein-Str. 9, 07745 Jena — [2]Jena Optronik GmbH, Prüssingstr. 21, 07745 Jena — [3]Max-Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn

Mapping objects at frequencies around one terahertz from a significant distance poses a considerable challenge for any imaging device. The power emission of bodies at room temperature is very weak, so a purely passive map requires an extremely sensitive detector. For sub-mm wavelength recently a big leap forward in the detector performance and scalability was driven by the astrophysics community. Superconducting bolometers and midsized arrays of them have been developed and are in routine use. It is conceivable that such devices will become larger, less costly and available for a wider market. So, a THz imager for industrial or security applications based on superconducting detectors comes into reach. Although devices with many pixels are foreseeable nowadays a device with an additional scanning optic is the straightest way to an imaging system with a useful resolution. Our superconducting THz imager (SCOTI) is a small cassegrain telescope with a scanning secondary mirror designed for a frequency of 0.34 THz. It can map objects from a distance between 5 meters and 20 meters using a small array of superconducting bolometers. The resolution at the object area is about 1 cm. Purely passive images of interesting objects can be taken, opening a wide field of applications.