Infrared Science and Technology Workshop 2022
Program Abstracts

Wednesday March 30, 2022

Dominic Benford - NASA Headquarters
Planning for Astrophysics in the 2020s and beyond
9:10-9:40 AM

With the long-anticipated Decadal Survey in Astronomy and Astrophysics released in late 2021, NASA's Astrophysics Division is planning to pivot in response to its recommendations. Most NASA missions are many years in the making, and so the changes in direction for major initiatives will roll out methodically over the next several years, while other recommendations will be implemented more visibly in the near future. I will present the context of ongoing projects, an overview of the recommendations, and preliminary plans for responding to them.

Jed McKinney - The University of Massachusetts, Amherst
Heating and Cooling in the Interstellar Medium of Dusty Galaxies
10:20-10:40 AM

Star-formation is regulated by the physical conditions of the interstellar medium (ISM) where gas cooling, heating and feedback from stars and active galactic nuclei (AGN) all compete to drive the evolution of galaxies. Mid- and far-infrared (IR) wavelengths host diagnostics of key physical mechanisms regulating star-formation, but these remain largely unexplored at cosmic noon (z~1-3), the peak epoch for star-formation, because of gaps in wavelength capabilities. In this talk, I will discuss the nature of star-formation in IR galaxies based on combined mid-through far-IR and radio spectroscopy. Compact IR-luminous galaxies at z~0 exhibit low heating efficiencies and high star-formation efficiencies, linking parsec-scale ISM properties of star-forming regions to the global evolution of the galaxy. I will present ongoing work to make comparable, albeit time-expensive, measurements at cosmic noon using ALMA and discuss how space-based spectroscopy with wavelength coverage up to ~475 um can statistically link the properties of gas and dust with governing scaling relations in galaxy evolution.

Johannes Staguhn - Johns Hopkins University
Detector developments for Mid- and Far-Infrared Instruments for Future Missions
10:40-11:00 AM

We will provide an overview of the detector requirements for future space far-infrared missions, such as the FIR Probe and a scaled version of Origins, as proposed by the Decadal Report. This will be followed by an introduction of current detector technologies and a discussion of the required technology development roadmap to mature these detectors to be ready for those missions.

Laura Sommovigo - Scuola Normale Superiore
Newborn but dusty: the puzzle of EoR galaxies
11:00-11:20 AM

ALMA observations have surprisingly revealed the presence of large amounts of dust in the first generations of galaxies in the Universe. Unfortunately, their dust temperature, Td, remains mostly unconstrained due to the few FIR continuum data available for individual sources at redshift z>5. This introduces large uncertainties in our knowledge of several high-z galaxy properties, namely their dust masses, infrared luminosities, and obscured fraction of Star Formation Rates (SFR). We have developed a new method that allows us to constrain Td using a single continuum data at 158 microns by combining it with the CII emission flux. With our method, one can analyze uniquely the ALMA CII and continuum detections, including those from the ALPINE and REBELS surveys. Our analysis allows us to extend for the first time the reported Td-redshift relation into the Epoch of Reionization (EoR). We find that Td mildly increases at higher redshift, and we physically motivate this trend with the decrease of gas depletion time at early epochs. A higher Td has testable implications: it reduces the tension between local and high-z IRX-β relation; it alleviates the problem of the uncomfortably large dust masses deduced from observations of EoR galaxies; it results in a larger obscured fraction of the SFR. JWST will play a crucial role in testing these predictions, by allowing us to constrain better the stellar masses, metallicities, and star-formation histories of high-z galaxies. These quantities, coupled with ALMA-based dust-mass estimates, will shed light on the possible dust production mechanisms at high-z.

Mike DiPirro - NASA Goddard Space Flight Center
A Far-IR Technology Roadmap Derived from the Origins Flagship Study
11:20-11:40 AM

The critical technologies below TRL 6 necessary for a low temperature far-IR mission will be described. These technologies focus on telescope and detector cooling and extremely sensitive detectors. To lower the telescope and instrument internal emissions to levels equivalent to the background astronomical emission up to about 600 microns requires operation at 4.5 K or lower. Spaceflight cryocoolers exist for cooling to 6 K with a 10-year life (JWST/MIRI) and 4.5 K with a 5-year life (Hitomi/SXS). Some improvements in this technology to achieve 4.5 K with 50 mW of cooling and a 10-year life is required. Far IR detectors also need improvements in performance and array size. The NEP required for imaging is ~3 x 10^{-19} W $Hz^{-1/2}$, whereas the NEP needed for the far-infrared spectrometer with its spectral resolution of R=300 is 3 x 10^{-20} W $Hz^{-1/2}$. Both instruments as designed for Origins required individual arrays with pixel counts from 6,000 to 10,000. Currently several pixel arrays have been shown to meet the NEP requirements and 1000 pixel arrays have reached 1x 10^{-19}. Sub-Kelvin cooling is required to cool various direct detector technologies such as TES (50 mK typical) and MKIDs (100 mK typical). Several μW of cooling is needed. Work is completing on a TRL 6 version of a continuous cooling adiabatic demagnetization refrigerator (CADR) that will meet these requirements. The components of this refrigerator and its electronic control are derived from the successfully flown Hitomi ADR and controller. Virtual duplicates are being prepared to be flown on XRISM in 2023 as well. IR Probe missions have reduced detector requirements allowing their technology to reach TRL 6 by the mid 2020's.

Emily Barrentine - NASA Goddard Space Flight Center
Integrated On-Chip Spectrometers for Future Longwave Far-Infrared Space Missions
1:30-1:50 PM

Spectroscopy on the longwave end of the far-infrared spectrum (273 μm < wavelength, λ < 700 μm) is fundamental to several science goals prioritized in the 2020 Astrophysics Decadal Survey, focused on our understanding of cosmic ecosystems. Emission lines at these far-infrared wavelengths uniquely trace the dust-enshrouded regions where planet and star formation take place. However, spectroscopy at these wavelengths leads to considerable architectural challenges in meeting the size, weight and power (SWAP) requirements of a space mission. Integrated "on-chip" far-infrared spectrometers offer a significant opportunity to reduce the volume and mass of these future spectrographs. Integrated spectrometers are implemented in compact 2D silicon (Si) chips using superconducting microstrip transmission lines, provide controlled optical coupling via planar slot antennas, and feature integrated kinetic inductance detectors (KIDs). Such on-chip spectrometers reduce instrument size by more than an order of magnitude compared to free-space gratings, while still achieving high efficiency and moderate resolutions. A brief survey of the current integrated far-infrared spectrometer technologies under development is presented, and paths for their development towards the requirements of future space missions is also suggested. The μ-Spec technology, a grating-analog spectrometer design which is currently in development for the EXperiment for Cryogenic Large-Aperture Intensity Mapping (EXCLAIM) balloon mission, is also described in more detail.

Tom Megeath - University of Toledo
Far-IR studies of Mass Accretion and Feedback Toward Low Mass Protostars
1:50-2:10 PM

Low mass stars are the dominant form of stellar mass produced in the baryonic cycles of galaxies, and they are important tracers of star and cluster formation. Yet, fundamental questions remain regarding how they accrete mass and the role of feedback in their formation. Using results with SOFIA and Herschel, we will discuss how current and future far-IR missions can resolve these questions. We will first show how far-IR observations are essential for understanding accretion variability and the fraction of mass accreted during luminous outbursts. In particular, far-IR data are needed to measure variations in luminosity and search for changes in protostellar envelope structure. We will then show how far-IR lines trace shocks from accretion driven outflows. We will show the strong correlation between these lines and the far-IR luminosity, overview the various diagnostics, and discuss how emission from these outflows can be distinguished from that from PDRs.

Phil Mauskopf - Arizona State University
Space qualified FPGA based readout electronics for superconducting detector arrays
2:10-2:30 PM

I will describe the development of high speed digital signal processing electronics for readout of kinetic inductance detectors and transition edge sensors on space-based and balloon-borne Far-infrared missions.

Jens Kauffmann - MIT Haystack Observatory
Paradigm-Shifts in Mission Design enabled by the SpaceX Starship
3:40-4:00 PM

The SpaceX Starship might completely transform the landscape for future space-based experiments. Truly revolutionary will be its ability to launch massive and voluminous experiments, thus reducing the need for time-intensive design work to minimize mass and volume — as well as its intended ability to retrieve and re-fly experiments. Starship is expected to make its first orbital flight in 2022, with regular service planned for the second half of the decade. Should Starship perform as intended, its abilities will completely reshape the technical framework within which the Astro2020 survey was executed. We outline the possible impact Starship could have on the operation of space telescopes and their technical development. Some of this discussion is based on an analysis of far-IR telescopes with flight heritage that were designed with reduced attention to mass, volume, and TRL.

Ella Sciamma-O'Brien - NASA Ames Research Center

On the Importance of Producing and Characterizing Laboratory Analogs of Cosmic Grains, Planetary Atmospheric Aerosols, and Surface Material

4:00-4:20 PM

Carbonaceous dust and aerosols have been observed in interstellar/circumstellar and planetary environments. Dedicated laboratory experiments have been developed to produce analogs of these solid materials under different experimental conditions (molecular precursors, temperature, pressure, energy source…). These experimental studies are key to investigating the physical and chemical processes that drive the formation of solid particles from gas and solid phase molecular precursors in astrophysical and planetary environments. They also allow the characterization of the physical, optical, and chemical properties of these laboratory-generated analogs, hence providing critical information that can be used as input parameters in models for the analysis and interpretation of observational data. Here, as an example of these laboratory efforts, we will present various studies that combined (1) experiments performed with the NASA Ames COSmIC facility to produce analogs of Titan's atmospheric aerosols and cosmic grains from gas phase molecular precursors, and (2) the characterization of these analogs with the NASA Ames Optical Constants Facility (OCF) to provide the real and imaginary parts of their refractive indices, n + ik, to the community, from the visible to the far-infrared (0.59–200 μm, 16,950–50 cm^{-1}). We will also discuss the importance of the wavelength and spectral range coverage of these optical constants, n and k, for their use in radiative transfer, atmospheric and reflectance models, and present a new effort to develop an Optical Constant database (OCdb) to provide this critical data to the scientific community.

Thursday March 31, 2022

Chris Walker - University of Arizona
Single Aperture Large Telescope for Universe Studies (SALTUS)
9:00-9:30 AM

SALTUS (Single Aperture Large Telescope for Universe Studies) is a Probe mission concept that employs a radiatively cooled, 20 meter inflatable aperture and cryogenic detectors to better understand our cosmic origins and the possibility of life elsewhere. The science objectives of SALTUS are to:

1) Trace astrochemical signatures of planet formation, habitable zones, and life.
2) Trace galaxy evolution and heavy element production over cosmic time.
3) Perform a census and probe the structure of supermassive black holes.

To achieve these objectives SALTUS will perform spectroscopic studies towards 100's of exoplanets, protoplanetary disks, galaxies, and solar system objects over a wavelength range from ~3 to 300 microns at moderate and high spectral resolution. The focal plane will include both coherent and incoherent detectors cooled by a closed-cycle refrigeration system. The telescope will employ a sunshield and be radiatively cooled to ~45K. Adaptive optics will be used to optimize performance at short wavelengths. SALTUS will have ~10x the collecting area of JWST and ~30x that of Herschel. The 20 meter aperture of SALTUS will be used as a space node for millimeter-wave VLBI observations of massive black holes in the Milky Way and beyond. The mission is designed to have a lifetime of > 5 years. With its large aperture and suite of instruments, SALTUS will provide a quantum leap in our understanding of the universe.

Jason Glenn - NASA Goddard Space Flight Center
Science and Mission Concept for the PRIMA Far-Infrared Probe
9:30-10:00 AM

There is an unprecedented opportunity for transformational astrophysics to be done with a far-infrared observatory utilizing a cryogenic, 2-meter class telescope and large arrays of sensitive superconducting detectors. Recognizing this, the Astro 2020 Decadal Survey's "Pathways to Discovery in Astronomy and Astrophysics for the 2020s" recommended a new line of astrophysics Probes, with a far-infrared Probe as one of two possibilities for implementation this Decade. We present aspects of the science case for a Probe, PRIMA – the PRobe Infrared Mission for Astrophysics, ranging from observations of protostellar and protoplanetary disks, to feedback and interstellar medium physics in galaxies, to the growth of stars, supermassive black holes, heavy elements, and dust through cosmic time. Options for instrumentation capabilities will be discussed, including high and moderate resolving power spectroscopy and spectral energy distribution mapping. The mission will have key projects and a broad guest-observer program. Opportunities for ongoing community participation in the mission definition will be discussed.

Asantha Cooray - University of California, Irvine
FIRSST: Overview of the Far-Infrared Spectroscopy Space Telescope Probe Concept
10:20-10:50 AM

FIRSST (Far-Infrared Spectroscopy Space Telescope) is a mission concept now under development for the 2023 NASA Probe Class Mission competition. FIRSST is led by the astronomical community with the intent to create a general purpose observatory, in the same spirit of the Spitzer Space Telescope, with the widest participation from NASA and federal research facilities, research institutes, and universities. FIRSST aims to enable far-IR spectroscopy between 30 to 560 microns, from low to very high spectral resolving power with the top scientific goals associated with g improving our understanding and addressing top scientific questions related to planet, star, and galaxy formation. The science requirements are derived to be those that are needed to address most of the key questions of the Astro2020 Decadal survey. This talk will summarize FIRSST mission, some of the top level science goals and requirements, and the anticipated instrument suite.

Dave Leisawitz - NASA Goddard Space Flight Center
The Space Infrared Interferometric Telescope (SPIRIT): A Far-IR Probe Candidate
10:50-11:20 AM

As conceived at the end of a year-long study, SPIRIT is a structurally connected interferometer operating in the wavelength range 25 - 400 microns offering unprecedented 0.3 arcsec resolution at 100 microns (scaling linearly with wavelength) and spectral resolving power ~3000 at all wavelengths. This NASA Probe-class mission was designed to: (1) learn how planetary systems form from protostellar disks, and how they acquire their inhomogeneous composition; (2) characterize the family of extrasolar planetary systems by imaging the structure in debris disks to understand how and where planets of different types form; and (3) learn how high-redshift galaxies formed and merged to form the present-day population of galaxies. A new science team is updating the science goals, and technical details are subject to change in light of progress made since the mission was studied in 2004. Today's technology is essentially ready for this mission. For details, see Leisawitz et al., Adv. Sp. Res, 40, 689 (2007) and related papers at https://asd.gsfc.nasa.gov/cosmology/spirit/mission_papers/mission_papers.html

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Matt Bradford - California Institute of Technology / NASA Jet Propulsion Lab
Instrumentation and Technology for PRIMA: a Far-Infrared Astrophysics Probe
1:30-1:50 PM

An actively-cooled telescope optimized for far-IR wavelengths offers a powerful opportunity to address a wide range of astrophysics questions spanning galaxy evolution to planetary system formation. We are developing the PRobe Mission for far-IR Astrophysics (PRIMA), a 2-3 meter cryogenic space-borne observatory to realize this potential for the community in the 2030 decade. This presentation focuses on the approach to the instrumentation and detector arrays for PRIMA, with aspects that are applicable to any mission concept targeting sensitive space-borne measurements. Both deep extragalactic and high-resolution galactic work driving the design of a dual-mode multi-band spectrometer covering the 25-330 micron range. The core of the spectrometer is a suite of 5 grating modules with resolving power between 100 and 300. Two approaches are under study for the high-resolution measurements, an FTS and an etalon suite, both of which work in concert with the grating modules. A wide-field spectro-photometric imager / polarimeter is also under study for achieving large number statistics on extragalactic populations, as well as multi-band dust polarization mapping. At the heart of both instruments are large arrays of superconducting detectors; we review requirements and goals for the arrays, and outline the attributes and challenges of the two primary approaches: transition-edge-sensed (TES) bolometers and kinetic inductance detectors (KIDs).

Meredith MacGregor - University of Colorado Boulder

A New Window on Planet Formation with Far-Infrared Spectroscopy

1:50-2:10 PM

Planets form from disks of dust and gas surrounding newly formed stars. The Atacama Large Millimeter/submillimeter Array (ALMA) has revolutionized our understanding of the structure and chemistry of these protoplanetary disks over the last decade. However, there are many open questions that ALMA cannot answer: How much material is available to form planets and how quickly does this process proceed? How is water inherited through the star and planet formation process? How does a planet's nascent environment determine its ultimate habitability and potential to host life? A new probe-class mission operating at far-infrared wavelengths would allow us to answer these questions for the first time. I will discuss how FIRSST (the Far-InfraRed Spectrocopy Space Telescope) will use low- and high-resolution spectroscopy modes to explore planet formation highlighting multiple science cases such as following the trail of water and weighing protoplanetary disks using HD.

Kevin Stevenson - Johns Hopkins Applied Physics Lab

Eyes on the PIE: Using Planetary Infrared Excess to Study the Nearest Potentially-Habitable Exoplanets

3:40-4:00 PM

The two most prominent exoplanet atmospheric characterization techniques, transits and direct imaging, have achieved tremendous success over the past 15 years despite representing only a tiny fraction of the total exoplanet population. Due to their limiting constraints (edge-on orbital alignments or young, self-luminous planets), these methods are unable to study our nearest, potentially-habitable neighbors. The only way to characterize the atmosphere of these unresolved, non-transiting exoplanets using current technology is with planetary infrared excess (PIE).

The PIE technique has been proposed as a means to detect and characterize the mid-IR thermal spectra of habitable-zone exoplanets using sufficiently broad wavelength coverage to uniquely constrain the stellar and planetary spectral components from spatially unresolved observations. We will present results from a case study involving Proxima Centauri b, a rocky planet residing within the habitable zone of our nearest stellar neighbor. Specifically, we will demonstrate how a 2-meter telescope at cryogenic temperatures can resolve the planet temperature/radius degeneracy and constrain the abundances of key habitability indicators, such as CO2, H2O, and O3.

This material is based upon work performed as part of NASA's CHAMPs (Consortium on Habitability and Atmospheres of M-dwarf Planets) team.

Avi Mandell - NASA Goddard Space Flight Center

MIRECLE: Mid-IR Concept to Study Non-Transiting Rocky Planets Orbiting the Nearest M-Stars

4:00-4:20 PM

We present simulations of the performance and science yield for the MIRECLE (MIR Exoplanet CLimate Explorer) mission/instrument concept, which incorporates a moderately sized (1 - 2m) cryogenic telescope with broad wavelength coverage (2 - 18 μm) and a low-resolution (R=50) spectrograph designed for extreme flux measurement precision. With its unique simultaneous NIR/MIR wavelength coverage and high photometric stability, MIRECLE would be capable of efficiently characterizing a statistically significant sample of terrestrial planets around the nearest M-stars, a number of which are potentially rocky habitable worlds.

Utilizing the new technique called Planetary Infrared Excess (Stevenson 2020, Lustig-Yaeger et al. 2021) will open up the opportunity for measuring MIR phase curves of non-transiting rocky planets around the nearest stars with a relatively modest telescope aperture. Spectroscopic characterization of terrestrial atmospheres around a sample of 30-40 nearby rocky and Neptune-like planets would provide constraints for the distribution of planets with tenuous vs. substantial atmospheres, on the inner and outer edges of the habitable zone, and climate models to assess the potential for habitability. Currently planned missions such as JWST and ARIEL will be limited in their spectroscopic characterization of HZ planets to wavelengths below 12 μm due to the design of their instruments, telescope operating temperature, and/or wavelength coverage – leaving a gap for a new IR mission to explore. We will present exploratory simulations of the overall science yields for several mission architecture and performance metrics.

Friday April 1, 2022

Margaret Meixner - SOFIA/USRA
SOFIA Opportunities for Astro2020 Priorities
9:00-9:20 AM

SOFIA is the only far-infrared observatory in the world for the next decade. It prepares the astronomical community both scientifically and technologically for Astro2020's ambitious future. The current and future science of SOFIA is exciting and compelling and it advances Astro2020 science by directly addressing one half of the decadal science priorities in all three science themes: Cosmic Ecosystems, Worlds and Suns in Context, and New Messengers and New Physics. Full Science traceability matrix can be found on our website: https://www.sofia.usra.edu/sites/default/files/2022-01/SOFIA_Traceability_Matrix.pdf The community can use SOFIA as an asset to train the next generation of astronomers and instrument builders who will define, develop, and use the future far-IR space observatories described in the Astro2020 report. This talk will cover an overview of SOFIA capabilities, observing and archival funding opportunities for scientists, and instrumentation opportunities for instrument builders. It will also show how these opportunities can help us prepare the community for Far-IR probes and the technology maturation program needed for an IR/far-IR great observatory such as an Origins Space Telescope.

Tirupati Kumara Sridharan - National Radio Astronomy Observatories
Sub-mm VLBI with SOFIA and Suborbital Platforms: Testing GR through M87 SMBH Photon Ring Detection
9:20-9:40 AM

While SOFIA and balloon borne sub-orbital platforms nominally target science in opaque atmospheric bands inaccessible from the ground, it is not recognized that they offer transformative advantages for sub-mm VLBI in atmospheric transmission windows. Prospective SOFIA-ALMA VLBI at 690 GHz opens opportunities for observing the predicted photon ring(s) towards the M87 supermassive black hole. This may be the only way to achieve such a detection, which offers tests of General Relativity under strong gravity, in the near term. The prospects and benefits for such VLBI observations in the 690 GHz window (and 345 GHz) are presented. Primary hurdles and potential pathways are briefly discussed. The concept is also applicable to balloon borne sub-orbital platforms. Further scrutiny and work to develop this concept and the opportunity would be very useful.

Bernhard Schulz - DSI, University Stuttgart
A German/European SOFIA Instrumentation Effort
9:40-10:00 AM

Except for JWST that is limited short of 30 micron, no mid/far-infrared space missions are planned, nor achievable within the next 10 years. Meanwhile only SOFIA and some balloon missions will provide new data in that important wavelength range with opportunities to fly state of the art instrumentation, increasing the TRLs for future space missions, supporting scientific goals of both ESA's Voyage 2050 report and the US Decadal Survey, and sustaining the associated special skill sets within the astronomical community that will be crucial once new infrared space missions become available again. The SOFIA instrumentation roadmap, published in spring 2021, has a 10 year scope that includes a detector upgrade of HAWC+ and the development of two new instruments for SOFIA, yielding substantial performance increases between factors of 4 to 10. This forward-looking approach was followed by a complementary effort by the German SOFIA institute, that held a science workshop in July 2021 to assess the German/European astronomical interests achievable by airborne platforms within the next ten years. A second more specialized workshop was held in November 2021, where, based on the science requirements established by the previous one, the state of the technology and adequate hardware solutions were discussed, that can also lead to an additional new instrument for SOFIA, built in Europe. This presentation will summarize the results of both workshops.

Jordan Wheeler - NIST Boulder
Broadband Kinetic Inductance Detectors for Far-IR Observations
11:00-11:20 AM

Brand new development of free space coupled kinetic inductance detectors (KIDs) for broadband far-IR observations designed to meet the needs of present and future telescopes, will be presented. Development is targeted to investigate the potential for upgrading the High-resolution Airborne Wideband Camera Plus (HAWC+) instrument on the Stratospheric Observatory for Infrared Astronomy (SOFIA) with KIDs; but development will undoubtedly benefit future far-IR missions as well. These detectors consist of backside-illuminated KIDs on a silicon substrate where the hybrid TiN/Al inductor forms a resistive wire grid with broadband absorption. Detectors can be configured to absorb in either 1 or 2 polarizations with a pixel filling factor of around 80%. A novel two-layer meta-material anti-reflection coating, and a sub-quarter-wavelength back short allow for greater than 80% detection efficiency over the ultra-wide 1-6 THz bandwidth. These detectors require no focal plane focusing optics such as feed horns or microlenses, do not require fragile membranes, and utilize proven and straightforward fabrication methods. The optical and microwave design of these detectors will be presented, and preliminary performance of test devices will be quantified. This information will be used to assess applicability of this technology for future far-IR telescopes.

Roberta Paladini - California Institute of Technology IPAC
On the Origin of the Initial Mass Function and the Importance of Near and Far-IR measurements
11:20-11:40 AM

It is usually assumed that the stellar initial mass function (IMF) takes a universal form and that there exists a direct mapping between this and the distribution of natal core masses (the core mass function, CMF). The IMF and CMF have been best characterized in the Solar neighborhood. Beyond 500~pc from the Sun, in diverse environments where metallicity varies and massive star feedback may dominate, the IMF has been measured only incompletely and imprecisely, while the CMF has hardly been measured at all. In order to establish if the IMF and CMF are indeed universal and related to each other, it is necessary to: 1) perform multi-wavelength large-scale imaging and spectroscopic surveys of different environments across the Galaxy; 2) require an angular resolution of <5 in the far-IR for cores; 3) achieve far-IR sensitivities to probe 0.1~$M_{\odot}$ cores at 2--3 kpc.

Reinier Janssen - NASA Jet Propulsion Lab

Large arrays of high-sensitivity Kinetic Inductance Detectors for the Terahertz Intensity Mapper

11:40 AM-12:00 PM

TIM, the Terahertz Intensity Mapper, is a NASA far-infrared balloon mission. Its scientific goal is to unravel the 3D structure of the dust-obscured star-forming Universe. It will achieve this by observing large parts of the southern sky using two long-slit (1 degree slit length) grating spectrometers, which cover the 240-317 um and 317-420 um wavelength bands, respectively, at a spectral resolution R~250. Each spectrometer will require a large format focal plane of ~3600 dual-polarization sensitive detectors that are photon noise limited at the 100 fW of loading expected during operation. I will present the design of a fully-aluminum low-volume lumped-element kinetic-inductance detector (KID) that incorporates a novel “chain-link” absorber design. Operating at 215 mK, I demonstrate that this detector achieves a photon noise limited performance at 100 fW of optical loading with a white noise spectrum down to 1 Hz. These detectors are anticipated to achieve a detector limited noise equivalent power of ~2e-18 W/sqrt(Hz) at optical loading of <10 fW (currently not reachable in our system). I estimate this detector limited NEP based on the measured optical response and true dark measurements of noise and quasiparticle lifetime. In addition, I will present the design of a quadrant array, four of which will make up a single focal plane, each containing ~900 hex-packed, horn-coupled KIDs. I will show the first measurement results of a quadrant’s performance.

Sae Woo Nam - NIST Boulder

Superconducting Nanowire Single Photon Detectors for Mid-Infrared Spectroscopy

1:30-1:50 PM

Recently, our group has developed superconducting nanowire single-photon detectors (SNSPDs) operating in the mid-infrared from 2 – 10 microns. In addition, multiplexing techniques have allowed for the fabrication of arrays consisting of 1024 pixels, which could potentially be useful for spectroscopy and imaging. The primary advantages of SNSPDs for space-based photometry in this wavelength range are high stability of detector gain as a function of temperature and bias current, true single-photon sensitivity, zero readout noise, and extremely low dark count rate. SNSPDs’ stability make them a prime candidate for transit spectroscopy. The development of SNSPD arrays at wavelengths out to 20 microns could also have applications for low-noise imaging, conventional spectroscopy, or nulling interferometry. We will discuss recent developments in extending wavelength sensitivity to 20 microns and kilopixel-scale arrays.

Gordon Stacey - Cornell University

Silicon substrate-based Resonant Spectrometers

1:50-2:10 PM

We are developing technologies for achieving high spectral resolving power in compact configurations by depositing metal mesh patterns on silicon substrates. The devices we are working on include fully tunable free-space cavity Fabry-Perot interferometers, low resonant order fixed wavelength metal/silicon/metal filters and high resonant order metal/silicon/metal devices that promise both high resolving power and spectrally multiplexing capabilities. Our work has focused on devices to be used in a variety of science applications in the far-IR to millimeter wave bands. We will present modeling results, the devices as manufactured and the latest test results from these devices.

Imran Mehdi & **Martina C. Wiedner** - Caltech/JPL & LERMA, CNRS, Paris Observatory

Heterodyne Technology for Future Space Missions

2:10-2:30 PM

Millimeter and submillimeter heterodyne receivers have been invaluable over the last 40 years and lead to many astronomical discoveries. Heterodyne receivers have flown on several space missions including Herschel and are an integral part of SOFIA, several balloon experiments as well as ground-based telescopes, such as ALMA. Heterodyne Receivers can easily reach very high spectral resolution of 10^6 or more, typically have 1000 to 10000 spectral channels and are the ideal tool to study spectral line emission. Historically heterodyne receivers have only a single spatial pixel, but this has been overcome by heterodyne arrays combining several to many spatial pixels (currently up to 64) with large numbers of spectral pixels (~ 1000 to 10000), i.e. 10^6 to 10^7 spexels. Heterodyne arrays are now an integral part of SOFIA, balloon experiments and ground-based telescopes, and their technology is now well enough advanced for space applications. In the talk we will give an overview of the heterodyne instruments one could envisage for space missions, their expected performance and required resources. We will also mention advantages and disadvantages of heterodyne array receivers as compared to direct detectors and for which applications they should be considered.
