**GROUND-BASED THERMAL INFRARED ASTRONOMY – PAST, PRESENT AND FUTURE**
**ON-LINE, 12-16 OCTOBER 2020**

# ABSTRACT BOOKLET


**Invited Speakers**

Olivier Absil
Almudena Alonso-Herero
Dani Atkinson
Bernhard Brandl
Leo Burtscher
Willem-Jan de Wit
Steve Ertel
Sergio José Fernández Acosta
Leigh Fletcher
Markus Kasper
Ulli Käufl
Nancy Levenson
Anne-Lise Maire
Alexis Matter
Gwendolyn Meeus
Andrea Mehner
Takashi Miyata
Koraljka Muzic
Chris Packham
Romain Petrov
Colette Salyk
Rainer Schödel
Alain Smette
Angela Speck

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Mitsuhiko Honda (Okayama University of Science, Japan)
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Background image: ESO VLT VISIR image of Apep
Credit: ESO/Callingham et al.

All Contributions are Listed in the Order in Which They Appear in the Programme

# Monday morning session 1

*Koraljka Muzic (Centra, Lisbon)*
**Science Highlights from ground-based thermal-IR astronomy**

The thermal infrared is the wavelength regime of choice for a broad range of astronomical disciplines: from the small scales related to the dust grain properties, over the bodies of our Solar System and extrasolar planets, the stars both young and evolved and structures surrounding them, all the way to the properties of the interstellar medium and large-scale dusty formations both in the Milky Way and in other galaxies. In this talk I will give an overview of the recent science highlights exploiting ground-based thermal-infrared facilities, to lay ground for more detailed discussions of these scientific achievements, presentation of the new results, and the bright future we see ahead.

*Bernhard Brandl (Leiden University)*
**Specific Challenges and Design Consequences for mid-IR Instruments on ELTs**

I will briefly introduce the fundamental limitations of modern mid-IR facilities, both from ground and in space, and highlight their unique discovery spaces. I will generally discuss the unique challenges that ELTs impose on mid-IR instruments, from adaptive optics and high-contrast imaging to the complex thermal infrared background and and alternatives to classical chopping/nodding techniques. I will use the specific examples of the planned ELT instruments METIS (ELT) and MICHI (TMT) to illustrate how these challenges impact their conceptual design and capabilities.

*Gwendolyn Meeus (Universidad Autónoma de Madrid)*
**Observations of dust and gas in protoplanetary discs**

Discs around young stars are the nurseries of planets in which dust particles growand gas either gets accreted or disperses until planets can no longer form. As an important part of the planet-formation puzzle, both dust growth and gas dispersing mechanisms need to be understood. In this talk, I will first present observationalevidence of dust growth in protoplanetary discs surrounding both low- and intermediate-mass pre-main sequence stars, relating dust properties observed at mid-IR (and millimetre) wavelengths with the disc geometry. Both ground-based and space-based observations will be highlighted. Next, I will present results from infrared observations of both atomic and molecular gas in intermediate-mass Herbig Ae/Be discs. Finally, I will compare the gas properties of Herbig Ae/Be stars with those of their lower-mass counterparts, the T Tauri stars.

# Monday morning session 2

*Olivier Absil (University of Liège)*
**Background subtraction in high-contrast imaging**

In this talk, I will describe the challenge of PSF subtraction in high-contrast imaging, and explain how it relates to the problem of background subtraction in thermal IR imaging. I will review the main image processing methods used in high-contrast imaging, and show that some of them can be readily adapted to the case of thermal IR background subtraction. I will also discuss some lessons learned on the operations of high-contrast imaging instruments, and how they could be applied to the case of thermal IR imaging.

*Lei Chen (Konkoly Observatory)*
**A new method to search for weak companions around young stars with mid-infrared interferometry**

Point sources have been detected in the circumstellar environments of young stars at as close in as ~0.1 arcsec, using ALMA or VLT/SPHERE, and have been interpreted as planets surrounded by circumplanetary disks. Detecting these companions in thermal infrared wavelengths will help to confirm the discoveries, and provide constraints on the parameters of planets and circumplanetary disks. At the large separation of ~0.1 arcsec, such companions are expected to leave sinusoidal ripples in correlated spectra from mid-infrared interferometry like VLTI/MIDI. An obstacle to detection of such ripples is that they are entangled with the silicate feature in the N band. We developed a method to detect the weak ripple signals by comparing the correlated spectra for a given target on baselines with similar length. With our method, companions with flux ratio of only several percent could be detected. Tests of the method have been performed using both mock data and real-world observational data.

*Thayne Currie (Subaru/NASA-Ames)*
**A New Type of Exoplanet Direct Imaging Search: SCExAO and Keck/Lp Survey of Accelerating Stars**

We present first preliminary results from a new exoplanet direct imaging combining Subaru/SCExAO in the near-infrared and Keck/NIRC2 in the thermal infrared. In contrast to blind surveys with GPI and SPHERE, our search targets stars showing evidence for an astrometric acceleration from the Hipparcos-GAIA Catalogue of Accelerations (HGCA). SCExAO/CHARIS data provide planet spectra; thermal IR data from an upgraded Keck/NIRC2 provide a long wavelength baseline and precise astrometric calibration key to clarifying the candidate's atmospheric properties, demonstrating common proper motion, and providing (with HGCA) a dynamical mass. Even in its infancy, our survey has already yielded multiple discoveries, including likely jovian planets.

*Florian Kirchschlager (University College London)*

**First L band detection of hot exozodiacal dust with VLTI/MATISSE**

For the first time we observed the emission of hot exozodiacal dust in L band. We used the new instrument MATISSE at the VLTI to detect the hot dust around κ Tuc at wavelengths between 3.37 µm and 3.85 µm. The dust-to-star flux ratio in L band amounts to 5 to 7 % and the spectral slope is $\alpha = 3.92$. We modelled the spectral energy distribution based on the new L band data alone and in combination with H band data (VLTI/PIONIER) published previously. In all cases we find 0.58 µm grains of amorphous carbon to fit the κ Tuc observations the best, however, also nanometre or micrometre grains and other carbons or silicates reproduce the observations well. Since the H band data revealed a temporal variability, while our L band data were taken at a different epoch, we combine them in different ways. Depending on the approach, the best fits are obtained for a narrow dust ring at a stellar distance in the 0.1 au to 0.29 au range and thus with a temperature between 940 K and 1430 K.

*Dominique Petit dit de la Roche (ESO)*

**Planets in a different light: the potential of direct imaging in the mid-infrared**

Over one hundred planets have been discovered through direct imaging in the near infrared. However, most planets with known temperatures are hot and emit most of their flux in the mid-IR. Imaging at longer wavelengths could help us put stringent constraints on planet's radii, temperatures and chemical compositions and distinguish between cloudy and clear atmospheres. Additionally, for very young systems circumplanetary disks are expected to be bright in the mid-IR. They could make planets down to a few Jupiter masses visible and provide constraints on planetary formation. In this contribution, we present the most sensitive mid-IR observations to date of young exoplanet systems using VISIR and NEAR, and discuss the implications of these non-detections for models of young circumplanetary disks. We also discuss the exciting prospect of detecting young exoplanets with METIS on the ELT, and the constraints on exoplanet atmospheres that can be derived with this new data.

# Monday poster presentations

*Róbert Szakáts (Konkoly Observatory, Research Centre for Astronomy and Earth Sciences)*
**SBNAF Infrared Database**

One of the goals of the Small Bodies: Near and Far (SBNAF) project was to create a database for thermal infrared observations of small bodies. We collected published thermal IR measurements for our selected samples of Solar System targets including data from large missions (e.g. catalogues based on Akari, IRAS and WISE observations) and also data from smaller scale and individual reductions (e.g. the Herschel Space Observatory measurements of near-Earth and main belt asteroids). A primary goal of this database is to help scientists working in the field of modeling the thermal emission of small bodies. However, the database has the option to include more data of Solar System small bodies which have been observed at thermal IR wavelengths from space or with ground-based instruments. Researchers who have infrared measurements can submit their published data to us and we can make it available in our database via our webpage, or VO tools.

*Wolfgang Brandner (Max Planck Institute for Astronomy)*
**MIR detection and characterization of giant planets around white dwarfs**

This poster explores the parameter space accessible (planet mass, age, and semi major axis) for ground- and space-based MIR observations of self-luminous giant planets orbiting white dwarfs. Compared to surveys around main sequence stars, direct imaging exoplanet studies around white dwarfs are less demanding in terms of contrast requirement and angular resolution due to 1) the lower intrinsics luminosity of white dwarfs, and 2) the adiabatic expansion of planetary orbits with initial semi major axis greater than about 5 A.U. during the mass-loss episode of the white dwarf progenitor.

*Kevin Wagner (University of Arizona)*
**Deep Imaging of Nearby Habitable Zones with VISIR-NEAR and an Upgraded LBT**

The ESO/Breakthrough-sponsored New Earths in the Alpha Centauri Region (NEAR) program recently completed the first ultra-deep stare on Alpha Centauri with the upgraded VISIR-NEAR instrument. In this talk, I will describe the data reduction and scientific results of the NEAR campaign, with a focus on challenges within the existing data and how performance can be significantly improved in a repeated campaign. I will also discuss on-going efforts to upgrade the mid-infrared capabilities of the LBT based on the lessons from NEAR, which would enable coordinated deep explorations for low-mass habitable-zone planets in both the Northern and Southern skies.

*Hamid Hassani (Institute For Research In Fundamental Sciences (IPM))*

**Mixing of the thermal dust and gas in the ISM of Magellanic Clouds**

Thermal free-free emission from warm ionized gas could be well estimated from the hydrogen recombination line (e.g. Ha). Mapping this emission is crucial to measure the rate of massive star formation and constrain the amplitude of the CMB foregrounds. However, they suffer from attenuation by dust. Thanks to the Spitzer/Herschel observations, we were able to study the dust mass and extinction. A key parameter in mapping this extinction is the dust filling factor, a fraction of dust that is actually attenuating the optical waves. We measure the dust filling factor in the ISM of the Magellanic Clouds for the first time. Taking advantage of MUSE/VLT observations, we calibrate this dust filling factor for both diffuse emissions and HII regions, finding a larger variation in HII regions than in diffuse ionized gas, and smaller than in the MW. This factor shows an anti-correlation with molecular gas surface density indicating the clumpiness of dust mixed with molecular gas in the HII regions.

*Padma Yanamandra-Fisher (Space Science Institute)*

**Multiple Approaches to Ground-based Thermal Astronomy**

Ground-based thermal astronomy of the diversity of celestial objects is not the same. The science gaps and state of knowledge provide both guidance and constraints on the needed measurements, and can include citizen science support to professional ground-based mid-ir/thermal observations and campaigns for correlative analyses. The analyses of the data acquired also need to be archived and mined to provide visual results that can be useful in the interpretation of physical observations.The professional-amateur observer connection is, therefore, very important to nurture and develop consistent procedures in both camps. These successful approaches are currently being used in various fields ranging from solar system studies (planetary atmospheres and rings to comets) and exoplanetary system observations and simulated laboratory studies. I will provide examples of successful approaches and scale them to the thermal observations needed.

# Monday afternoon session 1

*Nancy Levenson (Space Telescope Science Institute)*
**Future Opportunities for Space-Based Thermal Infrared Observations**

Going above Earth's atmosphere avoids many of the challenges of ground-based observations in the thermal infrared regime. I will focus on the opportunities coming soon with the James Webb Space Telescope and also describe other concepts in earlier stages of development.

*Colette Salyk (Vassar College)*
**Spectroscopy of gas-phase molecules in protoplanetary disks around low-mass stars**

In this talk, I'll discuss how molecular spectroscopy is used to study the formation of planets around low-mass stars. The planet formation environment has a range of densities, temperatures and radiation fields, and the process is stochastic, making chemical predictions difficult via modeling alone. Observations are therefore crucial for determining the chemical environment in which planets form. ALMA is studying outer disk chemistry, but dynamic range and resolution limitations prevent it from effectively probing the chemistry of the inner, terrestrial-planet forming regions, of disks. I'll discuss how IR spectroscopy from both space- and ground-based facilities, has been used to detect gas-phase molecules in disks, and describe what these observations have allowed us to learn about planet formation. In addition, I'll highlight some of the advantages provided by ground-based observations — namely, their ability to kinematically locate molecules, and to study their motions.

*Leigh Fletcher (University of Leicester)*
**The Giant Planets in the Thermal-Infrared**

Mid-infrared imaging and spectroscopy provides a powerful diagnostic of the atmospheric conditions on the giant planets of our Solar System, from their churning tropospheric cloud decks to their seasonally-changing stratospheres. Mid-infrared studies have revealed long-term cycles of atmospheric variability; eruptions of powerful convective storms; changes within long-lived vortices; and can even diagnose the aftermath of comet/asteroid strikes. Observations in the N and Q bands provide our only unique measurements of atmospheric temperature, composition, and cloud opacity, and yet all current (Juno) and future (JUICE) robotic missions to Jupiter lack this crucial capability. Ground-based observations (from ESO, Subaru, Gemini, and NASA's IRTF) therefore play a vital supporting role in observing these four worlds, and can even provide new discoveries at distant Uranus and Neptune, despite atmospheric temperatures approaching 50 K, and angular sizes of 2-4". Continued imaging and spectroscopy capabilities in the N and Q bands, over a 1-arcmin field of view, is vital for the continued exploration of these giant planets.

# Monday afternoon session 2

*Markus Kasper (ESO)*

**NEAR – technical analysis and lessons learned from a unique experiment**

In June 2019, ESO and the Breakthrough Initiatives carried out the NEAR experiment, a 100-hour campaign to search for low-mass planets in the Alpha Centauri system, utilizing high-contrast imaging in the thermal IR. This has been made possible by moving VISIR to the VLT-UT4 and using the Deformable Secondary Mirror for AO and N-band AGPM coronagraphy. We will present the NEAR concept, and report on the achieved sensitivity and contrast. The expected performance of NEAR will allow us to probe down to the mini-Neptune range, while reaching down to a true Earth analogue would require a more sensitive detector technology and multiple telescopes observing in concert. We will report on the data reduction efforts carried out by several independent teams, and present campaign results.

*Jozsef Varga (Leiden Observatory)*

**Uncovering inner disk asymmetries with VLTI/MATISSE**

The inner few au region of protoplanetary disks is the cradle of terrestial planets. Looking at this region provides insights into the early phase of planet formation: dust grain growth and coagulation. Interferometers working at mid-infrared wavelengths can resolve the thermal radiation from the warm inner regions, providing information on the structure of these disks at very high resolution. I will present early results from the guaranteed observing program for young stellar objects of MATISSE, the new VLTI instrument for the thermal infrared. One highlight is that based on an ongoing survey of Herbig AeBe stars, the L band (3 micron) brightness distribution of these disks is commonly found to be asymmetric (one-third of a sample of 21 observed systems). I will discuss the potential sources for the asymmetry, like binarity, illumination effects, or asymmetric disk structure, specifically addressing the case of HD 163296.

*Péter Ábrahám (Konkoly Observatory)*

**A sharp view of the silicates in the young outbursting star V900 Mon**

Mid-infrared interferometry is a powerful method to characterize the inner disk of a young stellar object. Based on high resolution measurements, we can determine disk geometry, search for companion, and study dust properties, including grain growth and crystallinity. As part of the interferometry program on young stellar objects at Konkoly Observatory, here we present new VLTI/MATISSE observations of V900 Mon, an FU Orionis-type young outbursting system. The data confirm the silicate emission feature, indicated by MIDI, and outline a radial variation of the feature's profile, which implies both grain growth and the presence of an absorption component in the innermost part of the system. We found no sign of crystalline silicates, thus the long-standing mystery of the lack of crystalline silicates in FU Orionis-type objects remains unsolved.

*Abigail Frost (KU Leuven)*

**Unveiling substructures in disks around massive young stellar objects**

Protostellar disks play key roles in the accretion process and formation of planetesimals for low-mass stars, and form various substructures, as different physical processes occur within them. Massive stars (M>8Mdot) form from the same clouds of dust and gas as low-mass stars and affect the both their own stellar environment and galaxies as a whole. Despite their importance, the formation of massive stars is poorly understood as they are deeply embedded, distant and rare, which introduces more observational challenges. While disks have recently been found around massive protostars massive disk evolution is yet to be constrained. In my talk, I will discuss our recent work which has, using a multi-scale analysis on a sample of massive young stellar objects (MYSOs), detected inner holes and gap-like substructures within the MYSO disks. I will also tie these geometrical traits to an independently determined evolutionary sequence and discuss what this means for disk evolution around MYSOs.

*Elena Kokoulina (Observatoire de la Cote d'Azur)*

**First MATISSE L-band observations of HD 179218. Is inner 10 au region carbonaceous?**

The initial conditions in planetary systems are inherited from protoplanetary disks properties. As they exhibit narrow emission bands in the MIR, polycyclic aromatic hydrocarbons (PAH) are good tracers of carbonaceous dust and consequently of the building blocks of life. PAHs can now be studied at small spatial scales thanks to the new VLTI MIR spectro-interferometer MATISSE.

We present the first MATISSE L-band observations of the Herbig Ae star HD179218. Its disk exhibits an unusual extended inner emission up to 10 au, which could be due to PAHs. We simultaneously modeled the SED and all the available interferometric data to provide a global view on the spatial structure of the inner disk region and give preliminary constraints on the location of the PAH-emitting region. Finally, in the perspective of upcoming MATISSE observations at higher spectral resolution we assess the feasibility of detailed characterization of the PAH emission in the 1-10 au region.

*Kevin Wagner (University of Arizona)*

**Thermal Infrared Imaging of Protoplanetary Disks and Substellar Companions with LBTI**

The Large Binocular Telescope Interferometer (LBTI) is one of the most sensitive infrared imaging facilities in the world. Combining the adaptive-secondary corrected wavefronts from two 8.4-m primary mirrors, the LBTI enables a novel array of background– and contrast-limited imaging modes. Recently, we've utilized the LBTI for two classical imaging surveys of 1) protoplanetary disks around Herbig stars in the Northern hemisphere, and 2) systems with known planetary-mass companions. These programs are still underway, and have already produced the first images of a new disk within Orion, and have significantly pushed the mass-detection limits in systems with known companions. In this talk, I will describe the results from these initial observations, our plan to improve upon the statistics of systems hosting disk substructures and substellar companions, and how we aim to utilize these as constraints on theoretical models of planet formation.

# Tuesday morning session 1

*Anne-Lise Maire (Univ. Liege/STAR Institute)*

**Lessons learned from NEAR for high-contrast imaging of exoplanets with ELT METIS**

The New Earths in the Alpha Cen Region campaign is a 100-h imaging search for massive rocky planets in the habitable zone of the two stars of Alpha Cen. The program is a collaboration between the Breakthrough Initiatives and ESO and was launched in 2016. To achieve the challenging goal of NEAR, the VLT MIR instrument VISIR was upgraded and installed at UT4 to couple it with the Adaptive Optics Facility. The University of Liege provided an optimized vortex coronagraph and a dedicated pointing control procedure. After a successful commissioning in April and May 2019, the campaign was completed in May-June 2019. It generated >6 TB of data, which are available to the community. The data were analyzed by the NEAR collaboration. I will present the science context of the project, simulated and on-sky results of the performance of the vortex coronagraph, the lessons learned for high-contrast imaging with ELT METIS, and prospects for imaging Earth-mass planets around Alpha Cen.

*Patrick Roche (Oxford University)*

**Dust properties, magnetic fields and grain alignment investigated via mid-IR polarimetry**

Polarimetry at mid-IR wavelengths provides unique information on dust properties. Here the effects of scattering are much lower than at shorter wavelengths and aligned non-spherical dust grains can produce absorptive and/or emissive polarisation. The spectral dependence of the polarization provides important information on grain properties while multi wavelength measurements allow absorptive and emissive components to be separated. Once the polarization mechanism has been identified, the polarization position angle may be used to infer the component of the magnetic field directions in the plane of the sky.

*Ryan Lau (ISAS/JAXA)*

**Revisiting and Resolving Carbon-rich Wolf-Rayet Dust Factories**

For decades, a subset of carbon-rich WR (WC) stars have been known to actively form dust despite their extreme environments. Although these systems can produce copious amounts of dust, they have been commonly overlooked as significant sources of dust in the ISM of galaxies in the local and early Universe due to the persisting mysteries on their dust formation and the influence of binary companions. In this talk, I will discuss the results and plans from our research program that combines archival data thermal IR observations, new imaging and spectroscopic data from Subaru/COMICS, and approved Early Release Science observations with JWST in Cycle 1. I will highlight our major results that uniquely combine a comprehensive dust SED analysis of Galactic dust-forming WC stars with Binary Population and Spectral Synthesis (BPASS) models and show that WC binaries are early sources and significant sources of dust at LMC-like and solar metallicities in constant star-forming environments.

*Ágnes Kóspál (Konkoly Observatory)*

**Grain Growth in Newly Discovered Young Eruptive Stars**

Young eruptive stars show large outbursts due to highly enhanced accretion from the circumstellar disk onto the protostar. We used VLT/VISIR to obtain the first thermal IR spectra of five recently discovered FUor-type young eruptive stars. We study the shape and strength of their silicate feature and find that they mostly contain large amorphous grains, suggesting that large grains are typically not settled to the midplane in FUor disks. This is a general characteristic of FUors, as opposed to regular T Tauri–type stars which display anything from pristine small grains to significant grain growth. We confront the observed silicate features in our targets with the evolutionary scenarios on envelope dispersal around young stars. In our sample, all Class II objects exhibit silicate emission, while for Class I objects, the appearance of the feature in emission or absorption depends on the viewing angle with respect to the outflow cavity, highlighting the importance of geometric effects.

*Stefan Kraus (University of Exeter)*

**A young triple star system with misaligned disk/orbit planes shaped by disk tearing**

We present VLTI+VLT+ALMA observations of GW Orionis, a T Tauri-star triple system with an inner pair (242 day period) and an outer companion (11 year period). We monitored the orbital motion of the stars and derived a full RV+astrometry orbit solution, which reveals that the orbital planes are misaligned with respect to each other. We imaged the circumtriple disc at near-infrared, mid-infrared, and sub-millimetre wavelengths and discovered four rings in thermal light and an asymmetric structure with radial shadows in scattered light. The inner-most ring is eccentric and strongly misaligned both with respect to the orbital planes and with respect to the outer disc. Based on the measured triple star orbits and disc properties, we conducted smoothed particle hydrodynamic simulations which show that the system is susceptible to the disc tearing effect. In this talk I will present yet-unpublished VLTI/MIDI inner disk modelling and discuss possible origins of the variability in the system.

# Tuesday morning session 2

*Ulli Käufl (ESO)*

**On the history of ground-based thermal-IR astronomy**

Since ~1980 until today, almost without interruption, ESO has been offering, state of the art thermal IR facility class instrumentation to its community. There was a stunning evolution from single pixel detectors to EFOSC/FORS-like multi mode instrumentation including high resolution Echelle spectroscopy. This was possible due to a rapid technical evolution in the fields of cryogenics and detectors. This allowed the adoption of classical optical designs, such as EFOSC to be used in a field then, and today(?), considered at best "exotic" by most astronomers. The ESO LaSilla instrumentation was the perfect match to Europe's groundbreaking infrared missions, the IRAS satellite and the ISO, the infrared space observatory.
I will give a short overview of instrumentation for mid infrared astronomy in use on LaSilla and Paranal and will make reference to other observatories.

*Benoît Tabone (Leiden Observatory)*

**Thermal infrared OH lines as diagnostic of H2O photodissociation in circumstellar media**

The thermal IR wavelength regime provides key information on inner planet-forming regions of disks (<10 au) around pre-main sequence stars. Observations from the ground, especially with VLT-CRIRES has unraveled rich organic chemistry operating in disk surface layers that can be used to hint of the on-going planet formation process and link it to the composition of exo-planets. However, any detailed analysis requires a fine understanding of the chemical processes operating in disks atmospheres, exposed to intense UV radiation.
In this contribution, we present a method to measure photodissociation rates of H2O from the observation of OH mid-IR lines. We discuss how to exploit the unique combination of high spectral and angular resolution offered by current (VLT-CRIRES) and future (ELT-METIS) infrared instruments to study the radial and vertical structures of disks. We also insist on the importance of collaborations with chemists to properly analyze near and mid-infrared molecular lines.

*Claudia Agliozzo (ESO)*

**Luminous Blue Variable stars as dust factories at sub-solar metallicities**

Luminous Blue Variable stars are blue supergiants that undergo instabilities and experience outbursts with high mass-loss rates. An extreme example is eta Car, that in the XIX century ejected more than 40 solar masses at rates higher than 0.1 Msun/yr. Several Galactic LBVs exhibit extended circumstellar nebulae, often with large masses of dust (~0.01 Msun). How this dust is formed is not well understood, but the physical conditions in their ejecta during the giant eruptions seem favourable for the formation and growth of dust. Thus LBVs are candidate producers of dust in the early Universe, where massive stars were more numerous than at present.

We carried out a pilot study of LBVs in the Magellanic Clouds (MCs) with ALMA and VISIR, and analysed the IR archival data of the full sample of Magellanic LBVs. We will show some results from this study, and discuss the importance of new thermal IR instruments, in synergy with sub-mm observatories, to evaluate LBVs as dust factories at low Z.

*Markus Wittkowski (ESO)*

**Investigating mass loss from evolved stars: First results and perspectives using VLTI-MATISSE**

Cool evolves stars, including asymptotic giant branch (AGB) red supergiants (RSGs) form molecules and dust in their atmospheres, which are subsequently expelled into the interstellar medium via stellar winds. For AGB stars, it has been shown that pulsation and convection lead to strongly extended molecular atmospheres, where the temperature is cool enough for dust to form. For RSGs, however, current dynamic model atmospheres of RSGs, based on pulsation and convection alone, cannot explain observed extensions of RSG atmospheres by far. Here, we present first preliminary results of our mid-infrared interferometric imaging of one AGB star, R Aqr, and one RSG, AH Sco, obtained with the newly available VLTI-MATISSE instrument during science verification and early science operations. We also present our plans to further follow up on evolved star imaging at near- and mid-infrared to constrain latest dynamic models of the mass loss process.

# Tuesday afternoon session 1

*Andrea Mehner (ESO)*

**Science highlights from ground-based infrared observations of massive stars**

While infrared observations are challenging from the ground given the very high background emission and strong telluric absorption, the size of ground-based telescopes provides superior angular and higher spectral resolution over space observatories.
Key scientific discoveries were made with ground-based infrared observations in the 1960/70s, such as detecting thermal dust emission around evolved and young massive stars and allowing the measurements of the angular sizes and shapes of dust shells. As a display of the potential of ground-based infrared observations in understanding the formation and evolution of massive stars, I will highlight some recent results obtained in the field of young dust accreting massive stars, and evolved dust producing objects like Red and Blue Supergiants, Yellow Hypergiants, and Luminous Blue Variables.

*Pierre Kervella (Paris Observatory)*

**The dimming of Betelgeuse**

In January-February 2020, our red supergiant neighbor Betelgeuse experienced an exceptionally deep photometric minimum at visible wavelengths. As it emerges from behind the Sun after the boreal summer, the apparent brightness of Betelgeuse is still at a low level. Betelgeuse is surrounded by a molecular and dusty envelope, that has been detected in the thermal infrared domain, in particular using VLT/VISIR and VLTI/MIDI. More generally, the close environment of Betelgeuse has been monitored from the ultraviolet to radio wavelengths using a variety of facilities, including adaptive optics and long-baseline interferometry. I will present an (incomplete) overview of the existing observations of the environment of Betelgeuse, with an emphasis on the thermal infrared domain, and how they could shed light on the recent dimming event.

*Julien Drevon (Observatoire de la Côte d'Azur)*

**Dusty circumstellar environment modeling around R Scl observed with VLTI/MATISSE**

Carbon-rich dust is known to form in the circumstellar environmement of R Scl. The probing of such a process is crucial to understand the enrichment in heavy elements of the galactic interstellar medium. Using the spectro-interferometric measurements of the VLTI/MATISSE instrument, we managed to locate the seeds of dust formation around this bright AGB star. Indeed, the angular resolution of the ESO/VLTI in the spectral bands of MATISSE allows to scan its close stellar environment. Using the DUSTY code we give the main physico-chemical and geometrical key-parameters of the dust shell in agreement with the spectral distributions of both the ISO flux at high resolution in the mid-infrared and the MATISSE visibility in the LM and N bands. In order to better reproduce the 3.2µm features revealed in the object spectra, we used an analytical simple model resolving the radiative transfer equation that allows us to estimate the physical properties of the molecular layer.

*Ian Crossfield (University of Kansas)*

**Isotopic Abundances of Nearby Dwarf Stars**

The measurement of isotopic ratios is a key tool that has been used to unlock the formation of our Sun, the Solar Sytem, and the nuclear processes within evolved, massive stars. High-resolution thermal-infrared spectroscopy of YSOs, molecular clouds, and the ISM reveal a wide diversity of 12C/13C and 16O/18O isotopic ratios, but in dwarf stars these ratios have been measured only in the Sun. I will present our team's successful use of 4-5 micron spectroscopy to open a fundamentally new window to peer into the atmospheres of nearby stars via abundance measurements of CO isotopologues, including the first such measurement in any main-sequence star beyond the Sun. This tool is isotopic abundance analysis, a novel but previously-untested path which may eventually permit the measurement of precise stellar and planetary ages, determining the history of exoplanetary atmosphere formation and mass loss, and informing future studies of exoplanetary oceans and biosignatures.

*Steph Sallum (University of California Irvine)*

**ELT Imaging of MWC 297 from the Co-Phased LBTI**

I will present 3.7 um imaging of MWC 297 from non-redundant masking on the co-phased Large Binocular Telescope Interferometer. MWC 297 is a Herbig Be star in the Aquila rift. Previous observational studies of this object primarily used simple modeling approaches to constrain its circumstellar morphology. The unique angular resolution (~17 mas) and Fourier coverage of the 23-meter LBTI allows us to robustly image scales down to ~7 AU. We place new constraints on complex circumstellar structure that can resolve previous tensions between imaging data and stellar vsin(i) measurements. We also detect a companion candidate with a projected separation of ~22 AU. I will discuss the imaging, constraints on the circumstellar morphology, and the properties of the companion candidate. This is the first model-independent image reconstruction of a YSO with an ELT, enabled by adaptive optics and active co-phasing of the two LBT apertures across a 23-m baseline.

# Tuesday poster presentations

*Narsireddy Anugu (University of Arizona)*

**High angular resolution imaging of Betelgeuse and AC Her with LBTI**

Large Binocular Telescope Interferometer (LBTI) instrument delivers sensitive observations in thermal infrared wavelengths, starting from H to N-bands. This talk will present Betelgeuse's adaptive optics imaging and non-redundant masking observations taken in several wavelength filters during its mysterious Great Dimming in 2020 Feb and Mar. We also combine complementary CHARA long-baseline interferometer H-band observations to image Betelgeuse surface and circumstellar environment. Second, we will present LBTI Fizeau imaging and CHARA long-baseline interferometer observations of a post-AGB, AC Her, showing its evolved circumbinary disk.

*Lisa Shepard (University of Missouri)*

**Circumstellar Dust around Oxygen-Rich Mira Variables with Maser Emission**

Asymptotic Giant Branch (AGB) stars are major contributors of cosmic dust to the interstellar medium. Understanding the formation of cosmic dust ejected from these stars is essential to understanding the broader topics of evolution and composition of stellar and interstellar objects in our universe. This project investigates the formation of circumstellar dust by using a sample of oxygen-rich Mira variables for which maser emission has been identified. Using high-resolution spectroscopy data along with ancillary data from the published literature, we explore a relationship between maser emission and dust spectral features for the sample. We have investigated these spectra via continuum elimination to determine whether trends exist between the maser emission and dust spectral features. This is achieved by matching the positions and widths of observed spectral features with those seen in laboratory spectra.

*Kengo Tachibana (University of Tokyo)*

**Investigation of mid-infrared long-term variability of dusty AGB stars by using AKARI and WISE data**

Asymptotic giant branch (AGB) stars are one of the main dust sources in the universe. Theoretical studies suggest that the stellar pulsation plays a role in the dust supply mechanism. In order to explore the relationship between the stellar pulsation and the dust formation, we have investigated mid-infrared variability of dusty AGB stars and OH/IR stars by using AKARI and WISE single epoch data. Long-term (from 2006 to 2011) variations at 18 μm were detected in 147 stars. Interestingly, [18 um] amplitude evaluated in this study shows clear correlation to the mid-infrared color of [12 μm]-[22 μm]. Stars with stronger pulsation have redder color at mid-infrared. The mid-infrared color corresponds to dust mass loss rate, and the [18 μm] amplitude depends on the stellar pulsation. This correlation may be a key to understand the dust mass loss mechanism around dusty AGB stars.

*Eckhart Spalding (University of Notre Dame)*

**Commissioning Fizeau Interferometry with the Large Binocular Telescope Interferometer**

The Large Binocular Telescope Interferometer offers Fizeau baselines up to 22.7 m in the thermal infrared, and observations in this mode are considered predecessors to ELT observations. Here we describe the technical challenges and current status of this mode, which has been increasingly used and sought-after in recent years.

*Isabelle Vauglin (CRAL - Observatoire de Lyon)*

**Dôme C: an outstanding site for thermal infrared astronomy**

It has been demonstrated that the atmospheric conditions at Dome C are exceptionally good : the natural seeing ε can reach ε ~ 0.3 arcsec,  the isoplanetic angle θ is twice or three times larger than any other observational site, and the background is extremely low in the infrared mainly due to the cold temperatures. The small telescope ASTEP, dedicated to exoplanet search, is already running at Concordia. But to make the best use of these exceptional characteristics, we propose to build a wide-field, high-resolution (~0.3 arcsec using Ground Layer Adaptive Optics) infrared (from 0.8 to 5 µm) off-axis telescope. With such a telescope, we'll have the highest possible dynamic range and angular resolution and wide-field imaging capabilities in the near- and thermal-infrared range to follow up the scientific programmes of extremely large instruments such E-ELT, LSST or Euclid.

# Tuesday afternoon session 2

*Angela Speck (University of Texas at San Antonio)*

**Modeling thermal radiation from cosmic dust: how to use lab data**

A major contributor to thermal IR radiation is cosmic dust. The nature of this dust strongly affects its production of and interaction with IR light. To determine the precise nature of cosmic dust, we use a combination of multi-wavelength ground- and space-based spectroscopy, imaging, lab data and modeling. Dust grains scatter, absorb and re-radiate light according to their optical properties, which are sensitive to e.g. the temperature, chemical composition, size, shape, and lattice structure of the dust grains. We discuss how to apply basic physics concepts to understand lab measurements, the way in which measurements are made, how simplifying assumptions commonly made in astronomy may cause problems. We show how lab-derived parameters can be directly or indirectly compared to astronomical observations. Finally, we examine the simplifying assumptions with the most commonly used “synthetic” optical properties for cosmic dust and highlight laboratory data to use as a replacement.

*Steve Ertel (University of Arizona)*

**Thermal infrared imaging with LBTI's LMIRCAM and NOMIC**

The Large Binocular Telescope Interferometer (LBTI) is a NASA-funded instrument of the LBT designed for high-sensitivity, high-contrast, and high-resolution infrared (1.5-13 µm) imaging. To carry out a wide range of high-spatial resolution observations, it can combine the two AO-corrected 8.4-m apertures of the LBT in various ways including direct (non-interferometric) imaging, coronagraphy (APP and AGPM), Fizeau imaging, non-redundant aperture masking, and nulling interferometry. It also has broadband, narrowband, and spectrally dispersed capabilities. In this talk, I review the current performance of the system that includes a near-infrared phasing camera, a 1-5 µm camera (called LMIRCam), and an 8-13 µm camera (called NOMIC). Then, I present the results of its two key surveys on nearby young exoplanets (LEECH) and exozodiacal disks (HOSTS). I end this talk by presenting several instrumental upgrades that are currently underway to improve and expand the capabilities.

# Wednesday morning session 1

*Leo Burtscher (Leiden Observatory)*
**Resolving the dust structures in AGNs**

Active galactic nuclei (AGNs) are among the most luminous mid-infrared (MIR) emitters in the universe. In nearby AGNs, this emission is mostly from warm dust on scales of a tenth to about 10 parsec. This dust surrounds the accretion disk and absorbs its light along half of all lines of sight. While the structure and dynamics of this dust are still largely unknown, it has become clear in recent years that the "torus" picture is too simplistic since the majority of MIR emitting dust is actually located in the outflow direction rather than in the equatorial plane of the AGN. I will summarise the science highlights from AGN observations in the MIR at the highest angular resolution, in particular with long-baseline optical interferometry. I will also discuss the discovery space for future high-resolution studies with VLTI/MATISSE and ELT/METIS.

*Almudena Alonso-Herrero (Centro de Astrobiología)*
**The AGN torus and beyond**

A major advantage of ground-based thermal infrared observations is the increased angular resolution when compared to contemporary infrared space facilities. Even for the nearest active galactic nuclei (AGN), we need angular resolutions below 1" to probe their nuclear/circumnuclear regions (tens to hundreds of parsecs). The mid-infrared emission of AGN on those scales stems from the dusty torus, AGN polar emission and/or nuclear/circumnuclear star formation activity. In this talk I will review the most important results on the torus properties revealed with thermal infrared instruments on 8-10m class telescopes. I will discuss these results in the context of on-going ALMA and future JWST observations of the molecular gas and dust in the nuclear regions of nearby Seyfert galaxies.

*Violeta Gámez Rosas (Leiden Observatory)*
**VLTI/MATISSE MIR interferometry to observe the dusty structures at the cores of AGNs**

This talk will show the first scientific results for the Seyfert 2 type galaxy NGC 1068 which was observed during the commissioning run of MATISSE. The most striking finding is the presence of two bright hot dusty centers with very different SEDs. Further analysis reveals that the "Torus" might not be clumpy after all. MATISSE, the second generation MIR spectro-interferometer at the VLTI, was commissioned in 2017 and started observations in April 2018. Its high resolution at L, M and N bands allows for a more complete study of the hot dust found at the so-called AGN torus. We will also cover the technical aspects of the observational strategies, data selection criteria and data reduction methods used for AGNs, including details on how to deal with the atmospheric fluctuations and the infrared background emission by the use of chopping, a BCD calibration and an OPD modulation, besides the reliability tests performed on the MATISSE pipeline with respect to faint sources.

*Jacob Isbell (Max Planck Institute for Astronomy)*

**A Subarcsecond L- and M-band Imaging Atlas of Local Active Galactic Nuclei**

We present the largest currently existing subarcsecond 3-5 micron atlas of 118 local ($z < 0.3$) active galactic nuclei (AGN). Each AGN was observed with VLT ISAAC in the L- and/or M-bands between 2000 and 2013. We detect 92 sources in the L-band and 83 sources in the M-band. We separate the flux into unresolved nuclear flux and resolved flux through two-Gaussian fitting. We report the nuclear flux, extended flux, apparent size, and PA of each source, giving upper-limits for sources which are undetected. Using WISE W1 and W2 photometry we derive relations predicting the nuclear LM fluxes for Sy1 and Sy2 AGN based on their W1-W2 color and WISE fluxes. Lastly, we compare the measured mid-IR colors to those predicted by dusty torus models SKIRTOR, CAT3D, and CAT3D-WIND, finding best agreement with the latter. We find that several AGN are bluer than models allow. We find that this is most plausibly stellar light contamination within the ISAAC L-band nuclear fluxes.

# Wednesday morning session 2

*Foteini Lykou (Konkoly Observatory, Research Centre for Astronomy and Earth Sciences)*
**The FU Orionis disk from the view of MATISSE/VLTI**

We will present the results of our observations of the eruptive protostar FU Orionis obtained with VLTI/MATISSE in L and N bands. Our snapshot observations are complemented by analytical modelling and 3D radiative transfer simulations that allow us to quantify the geometry (e.g., radial extent, density gradient, inclination) and chemical composition (e.g., grain size, dust distribution) of the accretion disk. We find a compact inner disk seen in the near-infrared within 0.5au, and an outer, flaring, passive disk that extends beyond 0.5au and is composed of amorphous silicates. We finally compare these results to previous studies from ALMA and the VLTI.

*Alexis Matter (Observatoire de la Cote d'Azur)*
**Spatially resolving the chemical composition of the planet building blocks**

The inner regions (0.1-10 au) of protoplanetary discs are the expected birthplace of telluric planets. In those hot regions, solids can experience cyclical annealing, vapourisation, and recondensation. Hot/warm dust grains emit mostly in the IR, notably in N-band (8–13 µm). Studying their chemistry with the new MIR VLTI instrument MATISSE, which can spatially resolve those regions, requires detailed dust chemistry models. Using radiative transfer, we derived IR spectra of a fiducial static disc model with different inner-disc (<1 au) dust compositions. The latter were derived from condensation sequences computed at LTE for three initial C/O ratios: 0.4 (subsolar), 0.54 (solar), 1 (supersolar). The three scenarios return very different N-band spectra that MATISSE should be able to discriminate. From that, we propose a first interpretation of N-band 'inner-disc' spectra obtained with the former VLTI instrument MIDI on several YSOs, and show recently obtained MATISSE N-band spectra.

*Gideon Yoffe (Max Planck Institute for Astronomy)*
**Longslit spectroscopy of Herbig Ae disks with VISIR-NEAR at the VLT**

In the scope of the "NEAR" program the VISIR instrument has been operated with the adaptive optics system on UT4, delivering close to 100% Strehl in the N-band. In addition to the planet detection experiment on the alpha Centauri system, for which NEAR was conceived, ESO offered AO-supported VISIR observations in several community-driven Science Demonstration Runs, conducted in September and December 2019.
This program encompasses N-band longslit spectroscopy observations targeting a sample of Herbig Ae star disks with known PAH emission, aiming to spatially resolve the PAH emission and measure their radial profiles, probing the structure of the disk photospheres.
We model the longslit spectra using various silicate species as well as PAHs as possible opacity sources, and explore the spatial extent of the emission. We succeed to resolve the PAH emission and make radial intensity profiles thereof.
We present first results of such profiles for 4 sources, out of a total of 8.

*Marko Stalevski (Astronomical Observatory of Belgrade, Serbia)*

**VLTI/MIDI and VLT/VISIR challenge the traditional paradigm of dust in active galactic nuclei**

VLTI/MIDI revealed that mid-infrared (MIR) emission in active galactic nuclei (AGN) on parsec-scale originates preferentially from the polar region, which should be free of dust according to the standard model. VLT/VISIR showed that MIR emission follows the same trend on the scales of tens to hundreds of parsecs. In the newly emerging paradigm, this emission is attributed to the dusty winds driven away by the radiation pressure. When facing such a potential game-changing moment, detailed case studies are of great importance. One such object is an archetypal obscured AGN in the Circinus galaxy. We proposed a model in which dust in this source is found in a compact thin disk and in a polar outflow shaped like hollow cone. Using radiative transfer simulations we produced synthetic observations of our model for MIDI and VISIR and found that it can explain the morphology on all scales and the entire MIR SED. These findings warrant further investigation of the IR thermal emission of AGN.

*Yanna Martins-Franco (Valongo Observatory (UFRJ))*

**Unveiling the emission of complex molecules in luminous infrared galaxies**

Infrared luminous galaxies are sites where the emission arises from star formation, active galactic nuclei (AGN; associated with supermassive black holes), or a combination of both. They contain large amounts of dust, which at the smallest scales, becomes micron-sized molecules known as Polycyclic Aromatic Hydrocarbons (PAHs). In the interest of studying the impact that these energy sources may have in the interstellar medium, we use a sample of dusty galaxies from GOALS and ATLAS surveys with IRS/Spitzer mid-infrared spectra to look at the PAH population, in terms of size and charge. We find that the PAH population is dominated by small and neutral molecules, and note variations in the proportion of charged and neutral PAHs for galaxies with stronger AGNs. Our results motivate the use of infrared and PAH features to study the radiation field in these dusty environments.

*Mariela Martinez (Korea Astronomy & Space Science Institute)*

**The subarcsecond nuclear NIR and MIR emission of nearby QSOs**

Quasi Stellar Objects (QSOs) are between the most powerful active galactic nuclei (AGN). However, at the optical range the high bright combined with their point-like morphology difficult the investigations about the possible interplay and connection between the physical process related to the AGNs (e.g., accretion) and its host galaxy (e.g., star-forming). Infrared (IR) wavelengths offer a spectral window, in which the contrast between these two components is the largest.
I present a summary of the results that we have been obtaining during the last years from study the putative dusty torus and the spatially resolved star formation in a sample of local QSOs. For these studies we used the near- and -mid-IR data (photometry and spectroscopy) from the cameras CIRCE, EMIR and CANARICAM on the 10.4m Gran Telescopio CANARIAS,

as well as ground-based ancillary data from the VISIR camera on the VLT, and spatial data from the HST/NICMOS and Spitzer/IRS.

# Wednesday poster presentations

*Małgorzata Bankowicz (Astronomical Observatory of the Jagiellonian University)*
**Local environtment of (U)LIRGs from the ADF-S**

[Ultra] Luminous InfraRed Galaxies (abbreviated as [U]LIRGs) are a rare class of galaxies characterized by a significantly higher star formation rate than other starforming galaxies. We present our measurements of properties and environments of a sample of 70 ULIRGs, LIRGs and normal star forming galaxies spanning over the redshift range 0.2 < z < 0.7, detected in the far-infrared in the AKARI Deep Field-South. We find that all these types of galaxies reside in low density environments regardless of their infrared luminosities. We find that both AGN fraction and dust temperature tend to increase with the local density in the case of ULIRGs (and ULIRGs only), while for all the investigated classes specific star formation rate increases with the local density. We analyse the consequences of our measurements for interpretation of mechanisms of ULIRGs activation and mechanisms behind the activity of this mysterious class of galaxies.

*Subhrata Dey (Jagiellonian University)*
**Modelling of spectral energy distributions of (U)LIRGS in infra-red and radio domains**

We present the results of modelling of SED of 11 LIRGs in infrared and radio domain. We characterized the physical properties of our galaxy sample by using CIGALE fitting code from FIR to FUV. Using our own measurements at 350 MHz and 610 MHz and the analysis of the archival data from the VLA archives, the radio SED covers two orders in frequency (150 MHz to 8 GHz). Our results are the following: 1) the median spectral index between 150 and 325 MHz is flatter (-0.34) than between 325 and 610 MHz (-0.6) and between 610 and 1400 is -0.64, the latter being close to the value of optically thin synchrotron emission, 2) the median values of AGN fraction, star formation rate, dust luminosity, and dust mass are, 1%, 30.153 M_sun/yr,6.231*10^37 W, and 5.1864*10^37kg respectively from the CIGALE modelling, 3) LIRGs with flatter low frequency radio spectra show smaller AGN contribution(~1%), indicating that the flattening is due to free-free absorption rather than AGN.

*Lindsay Fuller (University of Texas at San Antonio)*
**Deconstructing infrared emission in Active Galaxies using SOFIA/FORCAST and /HAWC+**

Dust and gas play key roles in obscuration and supplying the supermassive black holes (SMBH) in active galactic nuclei (AGN). Nuclear mid-IR emission has primarily been attributed an obscuring parsec-scale dust torus coplanar to the equatorial accretion disk. However, recent studies have found that some nuclear MIR emission is due to an extended dusty wind coincident with the narrow line region of some nuclei, possibly extending out to hundred-parsec scales. With 31.5 and 37.1 μm SOFIA/FORCAST photometry, we have constructed spectral energy distributions (SEDs) of the torus for a sample of AGN. We have also characterized the non-torus emission for a subset of our sample. The addition of SOFIA/HAWC+ 53–214 μm data to the SEDs at longer wavelengths requires an improved methodology in torus isolation. We aim to understand the nature of the extended emission on hundred-parsec scales so that we can accurately describe the components of IR emission in AGN.

*Michał Michałowski (Astronomical Observatory Institute, Adam Mickiewicz University)*

**Stellar masses of submillimeter galaxies: the need for mid-infrared**

Submillimeter galaxies (SMGs) are the most actively star-forming galaxies in the Universe. Their numbers and properties are sensitive to certain parameters of galaxy evolution models. Moreover, they allow us to study the star formation process at its extreme. Hence it is important to accurately measure their properties. One of the most basic characteristic of a galaxy is its stellar mass, and for these z>1 galaxies, the mid-infrared regime is fundamental observational information to constrain their mass.
I will highlight the importance of the mid-infrared which allowed the measurement of stellar masses of SMGs. I will review what we have learned from this, within 20 years after the discovery of SMGs. In particular, I will discuss the importance of SMGs for the star formation history of the Universe and the nature of their activity, inferred from their stellar mass functions, relation with star formation main-sequence, infrared light distributions, and comparison with other samples.

*Ilhuiyolitzin Villicana Pedraza (DACC NMSU)*

**Connection between the Circumnuclear Star-Forming Regions and the active nuclei in NGC 1068**

We obtain data of the Seyfert 2 galaxy NGC 1068 at J band between 1.35-1.32 μ using the 8.1m Gemini telescope and GNIRS IFU mode. We found the radial velocity and intensity maps for [FeII] λ 12570, Pa β λ 12814 and FeII λ 13201 lines of all the components. The gas emission has a double origin associated with photoionization by young stars or excitation by collisions, we found a high influence of shocks produced by the jet. The intensity of Pa β emission show that this component is ionized by a younger cluster or more massive stars. From the analysis of the velocity fields, the data related with the component one of Pa β are consistent with the presence of rotation which is displaced from the maximum continuous, our observations may point to the presence of a bar.

# Wednesday afternoon session 1

*Willem-Jan de Wit (ESO)*
**VISIR - operations, calibrations, and upgrades**

ESO's VISIR instrument aims to provide diffraction-limited observations at high sensitivity in three mid-infrared atmospheric windows: the M-band, the N-band, and the Q-band for both imaging and spectroscopy. The instrument has been in near continuous operations since 2005, undergoing a few game-changing upgrades over the years. In particular the major VISIR upgrade project lasting about two years until 2015. In ths presentation, I will present VISIR's operational model its versatility and limitations and describe the instrument's performance improvements over the years.

*Alain Smette (ESO)*
**Telluric correction with atmospheric models (molecfit)**

Molecfit is a general tool to correct for telluric absorption lines based on synthetic modelling of the Earth's atmospheric transmission. It combines a publicly available radiative transfer code, a molecular line database, atmospheric profiles, and various kernels to model the instrument line spread function. As a result, the standard deviation of the residuals after correction of unsaturated telluric lines is frequently better than 2% of the continuum.
In this presentation, I will briefly describe the tool and the current developments: (a) integration within the ESO pipelines, (b) various improvements, (c) deployment of radiometers at Paranal for precise measurements of the atmospheric temperature and humidity profiles. In particular, in some specific conditions, molecfit is able to blindly correct telluric lines to a high accuracy.

# Wednesday afternoon session 2

*Donaji Esparza Arredondo (Radioastronomy and Astrophysics Institute (IRyA), UNAM)*
**A two-phase AGN torus as constrained from X-ray and mid-Infrared observations**

To understand the active galactic nuclei (AGN) class diversity, the obscuration from some lines of sight of the inner parts of a geometrically and optically thick dusty gas torus is required. This torus is not spatially resolved even for the closest AGN. Currently, several models at mid-IR and X-ray wavelengths have been developed to describe the structure and distribution of this material. However, questions, including how the torus mid-IR and X-ray emission are related remain unanswered. Here, I will present the results obtained to compare the dust and gas distributions in a sample of nearby AGNs with NuSTAR and Spitzer spectra available. We find that the models that better reproduce the X-ray and mid-IR spectra are smooth and clumpy, respectively. These results reinforce the link between the mid-IR and X-rays in the context of the obscuring structure. Moreover, they are key for future mid-IR development, both from ground and space telescopes.

*Omaira González Martín (IRyA UNAM)*
**Study of the diversity of AGN dust models**

The dust component of AGN produces a broad infrared SED, whose power and shape depends on the fraction of the source absorbed, and the geometry of the absorber respectively. This emitting region is expected to be concentrated within the inner ∼5 pc of the AGN which makes almost impossible to image it with the current instruments. The comparison between SED and predicted models is one of the few way to infer the properties of this dust component. We explore the discrimination among the six currently available models and parameter restriction using synthetic spectra (Gonzalez-Martin et al. 2019A), and perform spectral fitting of a sample of 110 AGN with Spitzer/IRS (Gonzalez-Martin et al. 2019B). This talk will give tips for observers and modelers to actually answer the question: how is the dust arrange in AGN? This question will be one of the main subjects of future research with JWST in the AGN field.

*Enrique Lopez Rodriguez (SOFIA Science Center)*
**Infrared polarimetry of active galactic nuclei**

We investigate the role of magnetic fields in the unification scenario of active galaxies and detect the signature of a global toroidal magnetic field and a well-defined dusty structure in the core of radio-loud active galaxies. In contrast to these results, we found that the core of radio-quiet AGN are generally low polarized in the mid-IR (MIR) at scales of 10s of pc, while MIR polarization up to 6 percent is observed over extended structures along the narrow line regions (i.e. NGC 1068 and NGC 4151) at scales of 100 pc. We have learn that the MIR nuclear polarization of highly obscured objects arises from a self-absorbed MIR polarized clumpy torus and/or extinction from the host galaxy. For unabsorbed cores, MIR polarization arises from dust scattering in the torus and/or surrounding nuclear dust. I will present a review of what we have learnt from IR polarimetric observations of active galaxies and the prospects of this analysis using future extremely large telescopes.

*César Victoria (Instituto de Radioastronomía y Astrofísica, UNAM)*
**The complex dust structure in NGC 1068**

According to the unified model of AGN, there is a toroidal-shaped dust structure surrounding the nuclei of these galaxies, whose physical properties remain an open question in the field. We have studied this dusty structure in the type-2 AGN NGC 1068, fitting four different dust models to high spatial resolution mid-infrared spectra (N- and Q-band). We found that NGC 1068 has a complex dust structure, which cannot be fitted with a simple dust model. A statistically acceptable spectral fit was obtained with a dust model that incorporates a smooth distribution, with same parameters allowed to vary between N- and Q-band spectra. Based on these findings, we use the radiative transfer code, SKIRT to produce grids of the parameters based on the smooth torus geometry.
We obtained that the best explanation for the mid-infrared spectra is the combination of two tori coexisting in the same plane, one of them larger than other one. This result demonstrates how complex is the dust structure in AGN.

*Eckhart Spalding (University of Notre Dame)*
**Commissioning Fizeau Interferometry with the Large Binocular Telescope Interferometer**

This talk is about recent and future technical work to commission the Fizeau observing mode at the Large Binocular Telescope with the LBTI instrument. The Fizeau mode combines the beams from the two 8.4-m primary mirrors to generate a PSF that can in principle increase the resolution by a factor of ~3 compared to a single aperture. This mode is available for LBTI detectors sensitive to 1.5-5 um and 8-12 um. The LBT provides the longest Fizeau baselines in the world---up to 22.7 m---and aperture synthesis with the LBT has long been anticipated as a stepping stone to ELT observations. A number of technical challenges are described, as well as an overview of Fizeau mode observations up until now---which includes a science dataset of a nearby star in a first-ever trial of the filled-aperture Fizeau mode to perform high-contrast imaging. I describe the results of this process and outline avenues of possible future work.

*Jordan Stone (Naval Research Laboratory)*
**High Contrast 3-5 Micron Integral Field Spectroscopy with LBTI/ALES**

The Arizona Lenslets for Exoplanet Spectroscopy (ALES) mode of the LBTI/LMIRCam instrument provides high-contrast integral field spectroscopy in the 3 to 5 micron spectral range. This unique sensitivity allows ALES to probe the peak of cool exoplanet emission spectra, yielding the strongest constraints on exoplanet luminosity and effective temperature. The waveband also includes the fundamental transitions of both methane and carbon monoxide, making it the most sensitive to disequilibrium carbon chemistry. I will report on-sky commissioning results, including first science, our progress to incorporate coronagraphy with ALES, and our path to using ALES with the full 23 m aperture of the LBT.

*David Trilling (Northern Arizona University)*

**The refurbished MIRSI at NASA's IRTF**

MIRSI -- the Mid-Infrared Spectometer and Imager -- was last operational at NASA's IRTF on Maunakea nearly a decade ago. MIRSI provides imaging and spectroscopy in both the 10 and 20 micron windows. We have refurbished MIRSI with a closed-cycle cooler and performed a number of other upgrades to allow MIRSI to return to IRTF. There is also now a facility simultaneous optical imager. First light for the refurbished MIRSI was achieved in May, 2020, and the instrument should be available for general use later in 2020. In this talk I will present a brief review of MIRSI's capabilities and a status update.

# Thursday morning session 1

*Takashi Miyata (Institute of Astronomy, The University of Tokyo)*

**Mid infrared instrument MIMIZUKU for TAO 6.5m telescope**

The University of Tokyo Atacama Observatory (TAO) is a project to build a 6.5m telescope at the world highest (5640m) Chajnantor site. TAO has a mid-infrared camera and spectrograph MIMIZUKU as the first generation facility instrument. TAO/MIMIZUKU is a unique instrument and has advantages over existing mid-infrared instruments.
1) Wide wavelength coverage from 2-38 micron. Especially 28-38 micron wavelength range is accessible only from the 5km altitude TAO site.
2) Accurate monitoring capability. MIMIZUKU equips a newly developed opto-mechanical device Field Stacker. It enables simultaneous observations of two or more stars and improves photometric accuracy by realtime calibration of atmospheric transmittance.
In this talk I will present details, current status, and schedule of TAO/MIMIZUKU.

*Tsubasa Michifuji (University of Tokyo)*

**Photometric accuracy with Multi-Field imager in MIR wavelength**

MIMIZUKU is the mid-infrared camera mounted on TAO. It has a unique system, Field Stacker. This system has two Field-of-Views (FoVs) and enables us to observe a pair of distant targets simultaneously. By comparing them, we can accurately cancel the atmospheric absorption, and we aim to perform relative photometry with an accuracy of a few percent. To achieve this, precise flat fielding is important. However, in ground-based mid-infrared observations, the best way of making flat frames is not established.
We have developed a new method of making flat frames by using time variation of sky background. This method is applied to analyze the data obtained with MIMIZUKU at Subaru. The estimated error of the flat fielding reached to about 0.3%, and a photometric error of about 2% was achieved. The difference between these errors cannot be attributed to only shot noise and suggests that there would be other factors such as the spatial difference of the atmospheric absorption between the FoVs.

*Denis Defrère (University of Liège)*

**SCIFY: self-calibrated interferometry for exoplanet spectroscopy**

Recent radial velocity surveys suggest that the bulk of the exoplanet population is located within the snow line, which is inaccessible to 10-m class imaging telescopes at infrared wavelengths. While the ELT will significantly open the discovery space both in terms of angular resolution and sensitivity, a complementary approach is to leverage the long VLTI baselines. With an inner working angle approximately 100 (resp. 25) times better than current 10-m class single-dish telescopes (resp. ELTs), the VLTI offers a unique capability to directly observe the inner planetary regions around nearby stars. Following the first successful observations of exoplanets by long-baseline interferometry with GRAVITY and the success of nulling interferometers in the US, it is now time to build the first VLTI instrument

optimized for high-contrast observations. This is the goal of the SCIFY project recently funded by the European Research Council (2020-2025) and presented in this talk.

*Ioannis Politopoulos (Leiden University)*
**VLT/VISIR Calibration programme and stray light modeling**

For decades, the standard background subtraction scheme in ground-based thermal-infrared observations has been a combination of chopping and nodding. Since the thermal background stability of the ELT during nodding is currently unclear, we investigate an alternative background subtraction scheme using only chopping. Using data from VLT/VISIR we study the structure in chop-difference frames which is dominated by a gradient. In this research we determine the origin of this gradient with the aim to understand, qualitatively and quantitatively, the link between telescope structure and chopping residuals. To achieve that, we construct a simple model which describes the most significant warm emitter in the VLT pupil seen by VISIR (the folded M3 tower) and show that this structure is responsible for the observed gradient in the chopping residuals. We corroborate our findings by implementing this model -- and reproducing the effect -- in the ray-tracing software FRED.

# Friday morning session 1

*Takafumi Kamizuka (The University of Tokyo)*
**Engineering observations of MIMIZUKU at Subaru**

MIMIZUKU is the 1st-gen. mid-infrared instrument for the TAO 6.5-m telescope being constructed at the Atacama Desert in Chile. Its performance was evaluated through the engineering observations performed at Subaru in 2018. As a result, imaging and low-resolution spectroscopic modes in 7-25 micron wavelengths were confirmed to be fine, although the sensitivity was degraded by detector noise. We also tested the functions of a special optical device called Field Stacker mounted on MIMIZUKU. The device allows us to select and combine two arbitrary observation fields in the telescope field-of-view. By observing a science target and a calibrator with the Field Stacker, we can accurately correct the atmospheric absorption and precisely measure the brightness and spectrum of the target. Through the engineering observations, we confirmed that the Field Stacker improved the photometric stability and the quality of spectrum even in the Q band. We report the results and future plans of MIMIZUKU.

*Romain Petrov (Observatoire de la Cote d'Azur)*
**MATISSE, the thermal infrared VLTI instrument**

MATISSE is the 2nd generation VLTI general user instrument operating in the thermal infrared from 3 to 13 microns. It can be used for high angular resolution imaging and for model fitting of its spectro-interferometric observables to study AGNs, YSO and stellar physics. This talk presents and overview of MATISSE concept, science goal and first results and then focusses on its commissioning, performances, limits and potential, combined with some recommendation to MATISSE users in the Data Reduction, verification and calibrationn phase.

*Sergio Fernandez-Acosta (Gran Telescopio CANARIAS)*
**GTC/Canaricam: Recommissioning and lessons learned**

CanariCam is the facility multi-mode mid-IR (8-25 um) camera on the 10-m Gran Telescopio CANARIAS (GTC) on La Palma, Spain. It was designed and built by the University of Florida (UF – PI: Charles Telesco) and provides our community with imaging, spectroscopic and unique polarimetric capabilities at, or near, the diffraction limit of the telescope. Since 2012, it had been operating in queue mode at one of the Nasmyth focal stations, until it was temporarily decommissioned in 2016. Now, following an upgrade project, started in mid-2018 as a joint effort between GTC and the UF, it has been installed and recommissioned on a different folded-Cassegrain focus.
We will present an overview of the scientific capabilities and highlights of CanariCam@GTC, along with the lessons learned during its operation and recent upgrade activities, results from the technical observations, its current status, and prospects for the future, in the context of a very demanding Instrumentation Program

## Friday morning session 2

*Jean-Philippe Berger (IPAG, CNRS, Université Grenoble Alpes)*
**Mid-infrared heterodyne interferometry for planet formation studies**

The Planet Formation Imager (PFI) project is an international effort to define the architecture and the technological roadmap for a next-generation long baseline interferometric facility operating in the infrared. PFI aims at reaching an angular resolution and sensitivity sufficient to resolve the composition and kinematic properties of circumplanetary disks surrounding planets in the making. Although direct mid-infrared interferometry such as the one carried at VLTI is currently privileged for sensitivity reasons it comes at a price of a costly and complex infrastructure. In this presentation we will discuss how technological progresses in the field of mid-IR lasers, time synchronisation, high bandwidth mid-IR detectors and photonics correlation might render mid-infrared heterodyne interferometry competitive again while providing an important simplification of the infrastructure. We will end up comparing direct detection schemes with an heterodyne concept.

*Aleksandra Solarz (ESO)*
**Characterization of the effect of atmospheric parameters on the infrared sky at the VLT**

The knowledge about the external environmental conditions on science data quality is an essential aspect of mid-infrared ground-based observations. Before science observations are taken, a standard star must be observed to assess the sky transparency and background, which leads to significant telescope overhead.

With the data collected by NACO and VISIR instruments in M and L bands at Paranal, we perform a multivariate correlation analysis between the sky counts and different external conditions (i.e. precipitable water vapour, humidity and an indication of dust on the main mirror). Using machine learning methods to analyse multiple regression data, we show that by using external, current conditions during the night, we can predict the sky counts with good precision. The use of the skycalc tool to estimate the background is also described. Our findings can have important implications for the operations of the current and future VLT instruments operating at mid-infrared wavelengths.

*Amelia Bayo (UV/NPF)*
**Light mirror production in Chile**

Planet Formation research is blooming in an era where we are moving from speaking about "protoplanetary disks" to "planet forming disks" (Andrews+2018). However, this transition is still motivated by indirect (but convincing) hints. Up to date, the direct detection of planets "in the making" remains elusive with the remarkable exception of PDS70b and c (Keppler+2018; Mueller+2018; and Haffert+2019). The scarcity of detections is attributable to technical challenges, and even for the rare jewels that we can detect, characterization (resolving their hill spheres) is unachievable. The next step in this direction demands from near to mid-infrared interferometry to jump from ~100m baselines to ~1km, and from very few telescopes to 20 or more (PFI like concepts, Monnier+2018). This transition needs for more affordable telescopes to be designed, where the driving cost is given by the diameter of the primary mirror. Our approach to tackle this problem relies on the production of light mirrors.

# Friday afternoon session 1

*Dani Atkinson (University of Michigan)*
**GeoSnap: A 2048x1024 HgCdTe array covering 3-13µm**

GeoSnap is a new HgCdTe detector currently showing QE ~50% across 3-13µm. The device takes advantage of a ROIC currently operated at 85Hz full-frame readout across a 2048x1024 array, with larger sizes easily possible. This talk presents characterization of the first engineering-grade test device from Teledyne Imaging Systems, over the last year conducted at the Universities of Arizona and Michigan. I also describe science applications and planned deployment over the next year.

*Rainer Schoedel (Instituto de Astrofísica de Andalucía – CSIC)*
**The Galactic Centre in the Thermal Infrared**

The centre of the Milky Way is the nearest galactic nucleus and the most extreme astrophysical environment in the Milky Way. It is therefore of unique importance for astrophysics. In this talk I will review the history and state-of-the-art of thermal infrared observations of the Galactic Centre.

*Nadeen B. Sabha (Institute for Astro- and Particle Physics , University of Innsbruck)*
**VLT/VISIR Mapping of the Galactic Centre Massive Clusters**

The Galactic Centre (GC) is the only galactic nucleus we can observe in detail and the most extreme large-scale astrophysical environment of the Milky Way. It is a GTO target for MIRI/JWST as well as for METIS/ELT. The GC harbours three massive clusters that allow us to study the cluster-based star formation history in this region over the past 8 Myr. I will present and discuss our results from mid-infrared observations of the GC obtained in 2010, 2016, and 2018 with VISIR/VLT. The high-resolution (~0.3") multi-epoch N-band data (at 8.6 µm and 13 µm) cover a large FOV (~1'x1') of the nuclear stellar cluster, the Quintuplet and the Arches cluster, and regions in the Arched Filaments, hence providing the largest maps of these regions taken with ground-based MIR instruments.

# Friday afternoon session 2

*Chris Packham (University of Florida)*
**MICHI: A Potential Thermal-IR Instrument for the Thirty Meter Telescope**

With the imminent launch of the JWST, the field of thermal-infrared (TIR) astronomy will enjoy a revolution. It is easy to imagine that all areas of infrared (IR) astronomy will be greatly advanced, but perhaps impossible to conceive of the new vistas that will be opened. To allow both follow-up JWST observations and a continuance of work started on the ground-based 8m's, we continue to plan the science cases and instrument design for a TIR imager and spectrometer for early operation on the TMT. We present the current status of our science cases and the instrumentation plans, harnessing expertise across the TMT partnership.

*Michael Meyer (University of Michigan)*
**Adaptive Optics Assisted Mid-Infrared Imaging with Geosnap on MMT and Magellan**

We will describe the Mid-InfraRed Adaptive-optics(AO)-assisted Instrument Development (MIRAID), which enables us to refurbish the MIRAC cryostat with a new Geosnap mid-infrared detector creating MIRAC-5 for use on the MMT and Magellan. MIRAC-5 will be one of the only accessible 3-13 µm cameras in the world capable of high resolution/contrast imaging with advanced AO. We will characterize the mid-infrared fluxes of known gas giant planets, and attempt the first detections of ammonia, a key nitrogen-bearing species, in exoplanet atmospheres. We will also attempt to image forming protoplanets candidates embedded within circumstellar disks as well as direct detections of mature gas giant planets inferred through radial velocity observations. Ultimately MIRAID will help pave the way for future mid-IR instruments for the next generation ELTs. Our current schedule is to commission MIRAC-5 with the new AO system MAPS on the MMT in 2021 and follow-up with observations at Magellan in 2022.