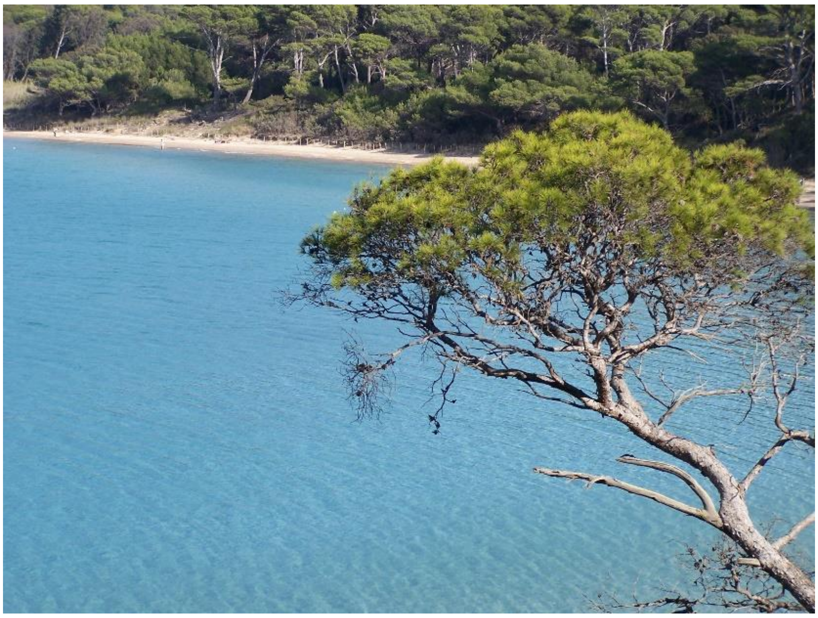
Stellar Intensity Interferometry Workshop 2024

September 9th – 13th, 2024

Porquerolles, France

Book of Abstracts

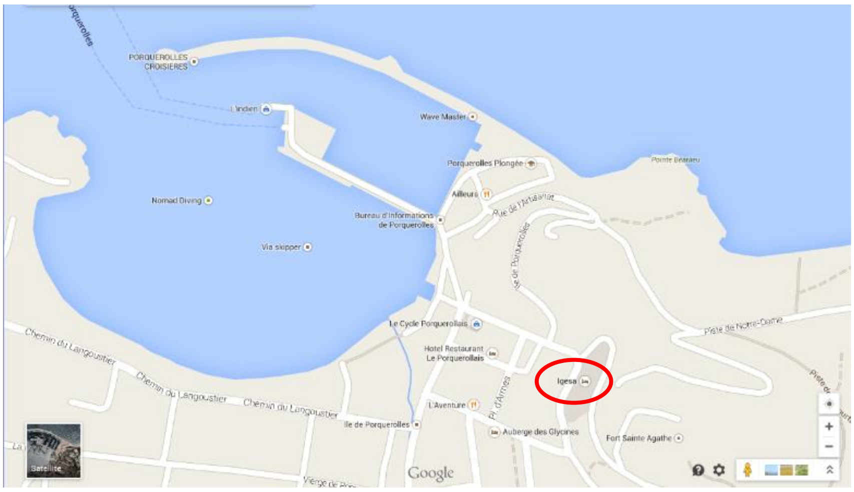


Practical Information

The meeting takes place at:

VILLAGE CLUB IGESA
Route de la douane
83400 Porquerolles

☎ : +33 4 94 12 31 80
@ : porquerolles@igesa.fr



The reception desk is open every day from 9:00 to 12:00 and from 17:00 to 19:00.

The bar is open from 11:30 to 14:30 and from 17:30 to 22:30.

The restaurant is open from 7:15 to 9:15 for breakfast, from 12:15 to 13:15 for lunch and from 19:15 to 20:15 for dinner.

Check-out: Please leave your room before 10:00

How to reach the organizers:

William Guerin, william.guerin@univ-cotedazur.fr, +33 6 47 33 61 25

Robin Kaiser, robin.kaiser@univ-cotedazur.fr, +33 6 29 07 71 92

Olivier Lai, olai@oca.eu, +33 7 68 88 77 40

Conference room:

All talks will take place in the “cinema” room.

Scientific program

See the last page for the time table

All durations are with questions included!!!

<u>Tuesday Morning session (8:45 – 12:30)</u>

Chair: William Guerin

Peter Tuthill: *The Narrabri Stellar Intensity Interferometer (1h)*

Mike Lisa: *An Introduction to Subatomic Intensity Interferometry for Stellar Intensity Interferometrists (30')*

Andrei Nomerotski & Sergey Kulkov: *Quantum-Enhanced Interferometers for Astrometry and Simultaneous HBT measurement at multiple frequencies (1h)*

Prasenjit Saha: *SII science cases: interestingness vs difficulty (30')*

<u>Tuesday Afternoon session (16:30 – 19:00)</u>

Chair: Olivier Lai

John Monnier*: Advances in "Amplitude" Interferometry (1h)*

Sebastian Karl & Verena Leopold: *Spatial photon correlations using nearly dead time free ultra-high throughput single photon detection (1h)*

<u>Wednesday Morning session (8:45 – 12:30)</u>

Chair: Stefan Funk

Juan Cortina & Alejo Cifuentes: *Intensity interferometry observations with MAGIC and the CTAO-North LSTs (1h)*

Andreas Zmija & Naomi Vogel: *Intensity Interferometry with the H.E.S.S. telescopes (45')*

Dave Kieda & Josie Rose: *The VERITAS SII Observatory (1h)*

Colin Carlile: *A Purpose-built Stellar Intensity Interferometer Array SIITAR for high angular resolution imaging (30')*

<u>Thursday Morning session (8:45 – 12:30)</u>

Chair: Joachim von Zanthier

William Guerin, Olivier Lai & Robin Kaiser: *Intensity Interferometry with optical telescopes: recent progress and future plans (1h15')*

Elisson de Almeida: *Testing the Wind Momentum-Luminosity Relation with Intensity Interferometry of Blue Supergiants (30')*

Jean-Philippe Berger: *Photonics correlation schemes for long-baseline all-fibered mid-infrared heterodyne interferometry (45')*

Nicolas Forget & Félix Gudin: *Broadband heterodyne detection for stellar interferometry (45')*

<u>Thursday Afternoon session (16:30 – 19:00)</u>

Chair: Guillaume Labeyrie

Nick Cvetojevic*: Title to be announced (1h)*

Roland Walter: *The QUASAR project: Resolving Accretion Disks with Quantum Optics (1h)*

<u>Friday Morning session (8:45 – 12:30)</u>

Chair: Robin Kaiser

Iman Zadeh: *Superconducting Nanowire Single Photon Detectors: state of the art, progress with arrays, and potentials for astronomy (45')*

Luca Zampieri, Michele Fiori & Alessia Spolon: *Final design and future upgrades of the Stellar Intensity Interferometry Instrument (SI3) for the ASTRI Mini-Array (45')*

Jonathan Biteau & Quentin Luce: *The Contribution of the Medium-Sized Telescopes of the Northern Site of the Cherenkov Telescope Array Observatory to Stellar Intensity Interferometry (30')*

Lionel Bigot: *Are 3D hydrodynamical simulations of stellar surfaces good enough for stellar limb darkening and interferometry? (30')*

All: *Closing remarks (30')*

Abstracts

The Narrabri Stellar Intensity Interferometer

Peter Tuthill

University of Sydney, Australia

In the early 1960's a new stellar interferometer - the first for a half century - began to emerge in dusty outback NSW. The highly unorthodox design was the brainchild of Robert Hanbury Brown and Richard Twiss and was led from the University of Sydney. The technology represents the culmination of a pioneering series of experiments originally performed in the radio at Manchester's Jodrell Bank. Although accepted by radio engineers, intensity interferometry was immediately controversial when performed in the optical, courting skepticism (and worse) from some of the most eminent physicists of the day. These critics were eventually silenced by the overwhelming success of the Narrabri Stellar Intensity Interferometer which made outstanding contributions to a wealth of fundamental stellar physics, such as the diameter and effective temperature scale for hot stars based on data only matched recently (more than a 60 years later). However, the most profound legacy is its place as the foundational experiment in the field now known as Quantum Optics. Recent years have seen a dramatic resurgence of interest in Intensity Interferometry, in part motivated by the availability of large collectors built for air Cherenkov arrays. Lessons from the past may help inform us of the future for this enduring technique

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An Introduction to Subatomic Intensity Interferometry for Stellar Intensity Interferometrists

Mike Lisa

The Ohio State University, USA

Seventy years ago, in 1954, Hanbury Brown and Twiss published their landmark article in Nature, establishing the formalism and groundwork for stellar intensity interferometry. A few months later, the antiproton was discovered at the Bevatron, heralding the new field of particle physics. In 1960, Goldhaber, Goldhaber, Lee and Pais noticed a tiny, "curious" feature in their first measurements of proton-antiproton annihilation which would eventually reveal a deep connection between these two seemingly disparate fields and a crucial tool for understanding the space-time evolution of high-energy heavy ion collisions. I will discuss the development of subatomic intensity interferometry, also known as "femtoscopy," as it has become a high-precision tool to extract the size, shape, timescale, and substructure of the quark-gluon plasma created at the Relativistic Heavy Ion Collider and the Large Hadron Collider.

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Quantum-Enhanced Interferometers for Astrometry

Andrei Nomerotski

Czech Technical University in Prague, Czech Republic

Correlations of photon pairs from entangled quantum sources offer advantages and provide additional opportunities in new sensing approaches in multiple fields. In general, strong spectro-temporal correlations inherent for entangled photons could make those sensing techniques much more precise and resource efficient. In application to astrophysics I will compare the standard techniques of single-photon amplitude (Michelson) interferometry and two-photon (Hanbury Brown & Twiss) intensity interferometry, and then visit recent ideas for how they can be improved in the optical through the use of entanglement distribution. A proposed new technique of two-photon amplitude interferometry requires precise spectral binning and 10 picosecond scale time-stamping of single optical photons and could improve the astrometric precision by orders of magnitude. I will illustrate the concepts with recent results and will discuss future directions for the technology.

[1] P Stankus, A Nomerotski, A Slosar, S Vintskevich, "Two-photon amplitude interferometry for precision astrometry"; Open Journal of Astrophysics 5 (2023).

[2] J.Jirsa et al. "Fast data-driven spectrometer with direct measurement of time and frequency for multiple single photons." arXiv:2304.11999 (2023).

Simultaneous Hanbury-Brown Twiss measurement at multiple frequencies

Sergei Kulkov

Czech Technical University in Prague, Czech Republic

Measurement of the Hanbury Brown-Twiss (HBT) effect is the corner stone of stellar intensity interferometry. Typically, it is performed using a very narrow spectral window selected by an optical filter. Measuring at multiple such windows can accelerate the process and improve the overall precision. We present a simultaneous HBT measurement using 5 different Ne spectral lines in a spectrometer with 0.1 nm resolution and with the LinoSPAD2 detector, which features a sensor of 512 SPADs, a 26.2 um pixel pitch, and 40 ps rms timing resolution.

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SII science cases: interestingness vs difficulty

Prasenjit Saha

University of Zurich, Switzerland

This presentation will argue that there are many more science cases for intensity interferometry than the applications that have been possible so far. Some, like resolving gravity darkening on stellar surfaces, would have considered futuristic in 1970 but not crazy. Others, such as resolving convective cells on stars were crazy in 1970, but merely futuristic by 2000 (thanks to developments in computing power and image reconstruction). Still others, such as probing the gravitational microlensing of quasars, may appear crazy even now...

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Advances in “Amplitude” Interferometry

John Monnier

University of Michigan, USA

I will present an overview of “Amplitude” Interferometry, also known as “Direct Detection” Interferometry, in the optical and infrared domain. By interfering light collected at widely-separated telescopes, astronomers can reconstruct images with milli-arcsecond angular resolution. After a review of the basic hardware and instrumentation used by the modern-day facilities CHARA and VLTI, I will highlight recent astronomical results including imaging of young stars, exoplanets, stellar surfaces, active galactic nuclei, as well as precision astrophysics using micro-arcsecond astrometry. Recent breakthroughs have been made possible by inclusion of modern photonics devices, new nearly-noiseless infrared detectors, and mastering of dual-star phase referencing. Some contrasts will be drawn between intensity, heterodyne, and direct-detection interferometry methods, as well as the emerging frontier of quantum-enhanced techniques. I will conclude my talk with a look into the future, focusing specifically on the Planet Formation Imager (PFI) and the Large Interferometer For Exoplanets (LIFE) Projects.

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Spatial photon correlations using nearly dead time free ultra-high throughput single photon detection

Sebastian Karl & Verena Leopold

University of Erlangen, Germany

Intensity interferometry recently benefitted from the improvements in (single) photon detection instrumentation. In this talk we present HBT measurements with a new kind of single photon detectors using a micro channel plate photo multiplier tube. The so called LINPix from Photonscore features an integrated constant frac6on discriminator and enables a quantum efficiency of greater than 35% at a wavelength of 405 nm. Together with a matching time to digital converter (TDC), LINTag, the detec6on system is able to operate at ultra-high count rates of up to 100 MHz. With this setup, previously tested in the lab, we were able to perform spatial photon correla6ons at the C2PU telescope (15m baseline) at the Calern observatory, Nice, France.

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Intensity interferometry observations with MAGIC and the CTAO-North LSTs

Juan Cortina & Alejo Cifuentes for MAGIC and CTAO LST collaborations

CIEMAT & Instituto de Astrofísica de Canarias, Spain

In addition to their regular gamma-ray observations at very high energies (20 GeV - 100 TeV), the two 17-m MAGIC telescopes have been operating as an optical intensity interferometer for several years. At the conference, we will discuss the calibration and validation of the instrument as well as first measurements of the diameters of 13 stars.

In 2024, the technical solutions implemented for MAGIC have been extended to the first Large-Sized Telescope of the northern hemisphere array of the Cherenkov Telescope Array Observatory (CTAO-North LST-1) of 23-m diameter, located near MAGIC in La Palma. We will present the first observations conducted using a combined LST-1 and MAGIC interferometer and delineate plans for forthcoming observations.

We are already making the same instrumentation ready for the next three LSTs, which should finish construction at the same site in 2025. We will discuss how the sensitivity and angular resolution will foreseeably improve with all six telescopes.

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Intensity Interferometry with the H.E.S.S. telescopes

Andreas Zmija & Naomi Vogel

University of Erlangen, Germany

Intensity Interferometry with the H.E.S.S. telescopes The H.E.S.S. intensity interferometer in Namibia observed southern sky stars in April 2022 and in April-May 2023, with future campaigns and upgrades in consideration. While in 2022 two telescopes operated in a single wavelength band, a third telescope was added in 2023 and observations were performed in two colors simultaneously. In this contribution we will compare both our setup configurations and present the latest results. We will discuss details of our analysis and potential sources of systematic errors. We will also introduce a project including a system of 1 m Fresnel lens telescopes situated on the roof of our institute in Erlangen.

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The VERITAS SII Observatory

Dave Kieda

University of Utah, USA

The VERITAS Imaging Atmospheric Cherenkov Telescope array was augmented in 2019 with high-speed focal plane electronics to allow VERITAS for Stellar Intensity Interferometry (VSII) observations. Since December 2019, VSII has been used to measure angular diameters of bright (OBA) stars at an effective wavelength of 416 nm. VSII observations have also served as a testbed to explore hardware and analysis improvements to advance the instrument's sensitivity. VSII has performed more than 730 hours of moonlit observations on 56 bright stars and binary systems ($-1.46 < m_V < 4.22$). This talk will describe the VSII observatory, highlight selected observations made by the VSII observatory, and describe ongoing improvements in detector instrumentation and analysis.

First indications of a non-round star with stellar intensity interferometry

Josie Rose

The Ohio State University, USA

Gamma Cassiopeia is a rapid rotator (believed to be 99% of its break-up velocity), as evidenced from spectroscopy and the extended decretion disk imaged at infrared frequencies. However, measuring the photosphere at optical wavelengths with stellar intensity interferometry has so far yielded only a measure of the average angular size of the star. VERITAS-SII uses four 12-meter telescopes to simultaneously sample 6 baseline vectors at various angles in the *u-v* plane. Between Jan 2023 and May 2024, more than 20 hours of SII data were accumulated on gam Cas. We will present the measurement details, the extracted correlations, and evidence for an anisotropic photosphere bulging at the equator, perpendicular to its angular momentum. The results are largely consistent with expectations based on infrared measurements and stellar models. This measurement is the first time that optical stellar intensity interferometry has extracted the size, shape, and orientation of a non-round star.

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A Purpose-built Stellar Intensity Interferometer Array SIITAR for high angular resolution imaging

Colin Carlile

Lund university, Sweden

Stellar Intensity Interferometry (SII) promises significant gains in angular resolution. Hanbury Brown et al. (1) measured the diameters of 32 MS stars with their SII setup at Narrabri at resolutions of ~2 mas. This iconoclastic work heralded the age of Quantum Optics. In order to realize the potential of SII further, arrays of 10s, 100s or even 1000s of telescopes (light collectors) located kilometers apart are required. The number of telescopes & their separations (baselines) determine the quality of the derived images.

Recently SII has undergone a renaissance. Data from existing Cherenkov arrays: VERITAS, H.E.S.S. & MAGIC are very encouraging. ASTRI, a 9-telescope array under construction, will access 36 static baselines, increasing to >400 as the target traverses the sky. Studies that edge towards an imaging of a bright Main Sequence star are on the horizon. With the Cherenkov Telescope South's potential 96 telescopes, angular resolutions of ~40µas will become possible. Recording ~50,000 baselines in a single night will yield detailed images of bright stars.

Intriguingly, even higher resolution images (~5µas) of bright MS stars would be obtained with a dedicated SII array. Here we present a concept for such an SII Telescope Array, SIITAR, with up to 2048 light collectors on a 19 km x 15 km elliptical footprint. We are inspired by the ambitious Deep Synoptic Array 2000 (2) to be built in the Nevada desert. Partnering with DSA-2000 on an already chosen site would reduce both construction time & cost, promising concurrent measurements in both the radio & optical bands.

1. R. Hanbury Brown, "The Intensity Interferometer", Taylor & Francis (November 1974)

2. Gregg Hallinan et al. https://www.deepsynoptic.org/overview

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Intensity Interferometry with optical telescopes: recent progress and future plans

William Guerin

Université Côte d'Azur, CNRS, Institut de Physique de Nice, France

I will present the current status of the work done by our "Intensity Interferometry at Calern" (I2C) consortium in Nice (France) on the revival of intensity interferometry with optical telescopes.

In short, we have demonstrated intensity correlations using stellar light for the first time in the photon-counting regime, using 1m-class telescopes at Calern Observatory. We have then dedicated some effort to demonstrate the simplicity and portability of our instrument by adapting and using it with success on different telescopes worldwide, including a 1-m portable telescope at Calern, the Auxiliary Telescopes at ESO-Paranal Observatory, and the 4-m SOAR telescope. Besides these technical demonstrations, we have also performed a few measurements of astrophysical interest, in particular on the Halpha emission line of P Cygni.

In addition, I'll present our short-term plans to improve the sensitivity: using superconducting nanowire single-photon detectors and performing wavelength multiplexing. Finally, I'll briefly introduce some of our long-term dreams, which will be the subject of the next talks!

OHANA NUI: Near kilometric baseline intensity interferometry on Maunakea

Olivier Lai

Université Côte d'Azur, Observation de la Côte d'Azur, CNRS, Lagrange Laboratory, France

Between 1999 and 2012, attempts to interferometrically connect optical/near-infrared telescopes on Maunakea using single mode fibres were carried under the OHANA project (Optical Hawaiian Array for Nanoradian Astronomy, `Ohana means family in the Hawaiian language). Astrophysical goals included the study of the accretion regions of Young Stellar Objects (YSOs) and Active Galactic Nuclei (AGN). Despite some early successes (coupling starlight into single mode fibres at CFHT, Gemini and Keck in 2002-2003, fringes between the two Keck telescopes using a pair of 300m single mode fibres for coherent transport, fringes between portable test telescopes connected by fibres - OHANA iki project), the effort was ultimately unsuccessful due in parts to vibrations inherent to a site not originally planned for interferometry, terrible weather misfortune and discovering that single mode fibres are extremely sensitive vibration sensors, picking up many waves of longitudinal o.p.d. over 300 meters. Current efforts for metrology through fibres at CHARA are now successfully overcoming the latter, but after 13 years of effort and the discontinuation of the Keck Interferometer, the team eventually moved on to other priorities in 2012.

Nonetheless, the foundation for a collaborative structure was laid and with the revival of intensity interferometry, the OHANA network has been rekindled for the direct measurement of the Sirius B White Dwarf, through the support of an ERC grant and the moral support of the Maunakea Observatories and University of Hawaii. I will present some of the site characteristics and infrastructures that make this the ideal site to carry out this exciting experiment!

Intensity Correlations for stars

Robin Kaiser

Université Côte d'Azur, CNRS, Institut de Physique de Nice, France

The pioneering experiments of intensity correlations by Hanbury-Brown and Twiss more than 50 years ago not only allowed to measure the angular diameter of many bright stars, but it also motivated Roy Glauber to develop his quantum formalism of photon statistics. The advent of direct optical interferences of light collected by different telescopes in the beginning of the 70s, with superior performances in terms of signal to noise ratio and reduced required observation time put an end to intensity correlation imaging for astrophysics.

In this talk, I will present a project to go beyond the angular resolution achievable at the VLTI, Chara or NPOI observatories, aiming to resolve a white dwarf using 2 telescopes at Mouna Kea in Hawaii.

I will also discuss how this single photon counting technique allows for detecting non thermal light sources (with corresponding photon bunching), such as lasing as expected in the vicinity of Eta Car, another project under development with novel superconducting single photon detectors

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Testing the Wind Momentum-Luminosity Relation with Intensity Interferometry of Blue Supergiants

Elisson de Almeida

Universidad de Valparaíso, Chile

Blue supergiants (BSGs, OBA supergiants) are a crucial phase in the evolution of massive stars, resulting from the rapid evolution of O-type main sequence stars that have exhausted their core hydrogen. They reach this stage either directly from the main sequence or after an initial Red Supergiant phase. The Wind Momentum-Luminosity Relation (WLR), an empirical relation between the stellar luminosity and the momentum carried by their stellar winds, serves as a crucial tool for estimating distances to massive stars. However, the accuracy of the WLR and its dependence on factors such as metallicity and mass-loss rates, which can vary significantly among BSGs, remain subjects of ongoing investigation, potentially limiting its predictive power. In this talk, I will present the results of a recent study where we successfully applied intensity interferometry, combined with spectroscopic measurements and radiative transfer models, to determine the distances to the blue supergiants P Cygni and Rigel. Building on these findings, I will discuss the prospects for a study aimed at extending this method to a larger sample of Blue supergiants. By comparing the derived distances with those predicted by the WLR, we will assess the validity of this relation across a wider range of stellar types and luminosities. This study has the potential to refine our understanding of the WLR and its applicability for distance determination, as well as shed light on the fundamental parameters of stellar winds in massive stars.

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Photonics correlation schemes for long-baseline all-fibered mid-infrared heterodyne interferometry

Jean-Philippe Berger

Université Grenoble Alpes, IPAG, France

Long baseline heterodyne interferometry in the mid-infrared offers an interesting alternative to direct interferometry by providing a much simpler infrastructure scheme. However, it suffers from a very significant sensitivity deficit with respect to the latter that can only be compensated by using very high bandwidth (> 10 GHz) detectors and mid-infrared frequency combs. In addition, it is more suited for an array of a high number of telescopes. In this presentation we will give an update of our current effort to elaborate a laboratory proof-of-concept of an all-fibered mid-infrared kilometric correlation scheme.

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Broadband heterodyne detection for stellar interferometry

Nicolas Forget

Université Côte d'Azur, CNRS, Institut de Physique de Nice, France

The coherent detection and correlation of noise-like signals are at the very heart of aperture synthesis in radio astronomy and the extrapolation of heterodyne detection to infrared or visible wavelengths has been sought for decades. Unfortunately, compared to direct detection, heterodyne detection suffers from a lack of sensitivity at optical wavelengths, because of (1) fundamental quantum noise and (2) narrow instantaneous detection bandwidths. On the other hand - and unlike direct detection - heterodyne detection offers the unique possibility of recombining a large number of distant telescopes without any loss in signal-to-noise. In this talk we discuss the benefits of using trains of ultrashort pulses (frequency combs) to perform heterodyne detection for optical stellar interferometry. Beyond an increase of the signal-to-noise and a bandwidth extension linked to the use of a set of local oscillators instead of a single local oscillator, ultrashort pulses may also simplify path equalization and dispersion compensation as well as relax phase stability constraints.

A two-beam, all-fiber, broadband heterodyne interferometer in the H-band

Félix Gudin

Université Côte d'Azur, CNRS, Institut de Physique de Nice, France

We present the first experimental results of the heterodyne detection of broadband incoherent light (ASE source) by a train of ultrashort pulses at telecom wavelengths (~1.56 µm) with a 22-GHz balanced detector and a 30-GHz oscilloscope. By using commercial polarization-maintaining fiber components, a simplified two-beam heterodyne interferometer is built. By numerically correlating the fluctuations of the two IF signals for different optical paths lengths between the two arms, we retrieve the interferometric signal (fringe visibility and coherence length) of the ASE source for various input light levels.

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TITLE TO BE ADDED

Nick Cvetojevic

Université Côte d’Azur, Observation de la Côte d’Azur, CNRS, Lagrange Laboratory, France

Abstract to be added.

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The QUASAR project: Resolving Accretion Disks with Quantum Optics

Roland Walter

University of Geneva, Switzerland

Accretion flows aroud black-holes, neutron stars or white dwarfs are studied since almost 60 years. Although they are ubiquitous and somewhat similar over scales reaching billions in mass and size, their study has been limited because they remain unresolved point like sources in the optical/ultraviolet and X-rays, where they emit. Two main modes of accretion have been identified in Active Galactic Nuclei. In most sources the accretion rate is low and a high pressure, low density, low collision rate, optically thin, radiatively inefficient, two temperature plasma can form (Shapiro 1976; Narayan & Yi 1994,1995). This solution is stable only for low luminosities (<1% LEDD). The Event Horizon Telescope has recently resolved such flows in Sgr A* and M87, confirmed several aspects of the model and could detect particles accelerated close to the horizon of Sgr A* (Wielgus, 2022) a likely signature of the Blandford-Znajek (1977) process. When the accretion rate is higher, momentum can be dissipated by viscosity and the flow proceeds via geometrically thin disk-shaped structures. These accretion disks provide feedback to their environment by accelerating winds and launching jets in their central regions. The apparent size of accretion disks are of the order of 1-40µarcsec in nearby quasars, Seyfert galaxies and galactic cataclysmic variables and of 0.1-1µarcsec in of low mass X-ray binaries in our Galaxy. Hanbury-Brown & Twiss (1954) invented intensity interferometry and measured the size of some bright stars by correlating the arrival times of photons detected by two optical telescopes. The physics has been explained as a quantum effect in the early 60s (Fano 1961) and has triggered the development of quantum optics (Glauber 1963). Its root is found in the quantum theory of statistical fluctuations in an ideal gas (Einstein 1925). The achievable signal-to-noise depends on the telescope size, the detector time resolution, and the number of spectral channels observed simultaneously. Extremely large telescope and 10ps resolution single photon detectors bring the key improvements to reach in the optical angular resolutions better than these achieved in the radio by the Event Horizon Telescope and to obtain the first images of accretion disks around galactic and extragalactic compact objects, a breakthrough.

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Superconducting Nanowire Single Photon Detectors: state of the art, progress with arrays, and potentials for astronomy

Iman Zadeh

Technical University of Delft, The Netherlands

Superconducting nanowire single photon detectors (SNSPD), thanks to their excellent detection efficiency (>98%) and time performance (1-10 ns deadtime and <10ps time jitter), are the leading detection technology in quantum photonics and are slowly finding their way in other fields such as fluoresce microscopy. SNSPDs have also been recognized as a promising candidate for next generation detection technology in the fields of visible and infrared astronomy. Intensity interferometry, for example, can benefit from detectors with high detection efficiency and high time resolution. The main challenge for the future SNSPD systems in astronomy is the limited detector size. Recent efforts have tried to address the issues regarding active area of SNSPD sensors. In this talk I will review basic physics behind SNSPD operation and briefly discuss their current state-of-the-art and finally will touch on current efforts to develop them further for application in astronomy.

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Final design and future upgrades of the Stellar Intensity Interferometry Instrument (SI3) for the ASTRI Mini-Array

Luca Zampieri

INAF - Osservatorio Astronomico di Padova

Abstract: The ASTRI Stellar Intensity Interferometry Instrument (SI3) is a fast single photon counting instrument for performing intensity interferometry observations of bright stars with the ASTRI Mini-Array. SI3 is designed to perform accurate measurements of single photon arrival times (1 ns) in a narrow optical bandwidth (1-8 nm) centered at a wavelength in the range 420-500nm. The instrument will take advantage of the 36 simultaneous baselines of the ASTRI Mini-Array over distances between 100 m and 700 m, enabling detailed observations of stellar surfaces of bright stars and their surrounding environments with angular resolution below 100 micro-arcsec. During 2023 SI3 underwent a significant redesign, with an optical fiber positioned on the focal plane to feed the detectors and electronics. This talk will show the new baseline design of SI3, and the rationale behind this choice, highlighting the innovative features of the instrument and the potential future upgrades, such as a custom-designed detector and Front-End Electronics (FEE), and channel multiplexing.

Assembly, Integration, and Verification of the laboratory prototype of the ASTRI Stellar Intensity Interferometry Instrument (SI3)

Michele Fiori

INAF - Osservatorio Astronomico di Padova

Abstract: The development of the ASTRI Stellar Intensity Interferometry Instrument (SI3) includes the crucial phase of Assembly, Integration and Verification (AIV) of all of the sub-components of the system, such as the Back-End Electronics (BEE) and the detectors. The BEE performs the accurate processing of the arrival times of photons acquired from the detectors and is essential to ensure the high temporal resolution required for intensity interferometry measurements. The process of integrating these systems involves a careful verification of the performance of all electronic and non-electronic components, including the recently redesigned optical system. These activities were carried out over the past few months through the implementation of a prototype laboratory instrument, in which all key system components were thoroughly tested. The insights gained in this phase are fundamental for the future development and implementation of SI3. This talk will provide a detailed update on the current status of these activities.

Simulations and analysis of ASTRI Stellar Intensity Interferometry Instrument data

Alessia Spolon

INAF - Osservatorio Astronomico di Padova

Abstract: In parallel with the finalization of the instrument design and the AIV activities on the laboratory prototype of ASTRI SI3, we are also working on the implementation of efficient data analysis techniques and realistic data simulations. This talk will outline the critical steps needed to achieve the ultimate goals of the ASTRI SI3 project: the synthesis of bright star images using a photon counting approach. We are now at the optimization stage of the data processing algorithm specifically designed to handle the extremely high count rates achieved with each individual telescope of the array. We developed also a simulation software to assess the performances of SI3. The results of the simulations show that stars with angular diameters less than 500-600 microarcseconds will be observable down to about magnitude 4.5. With the 36 simultaneous baselines of ASTRI, it will be possible to obtain accurate angular measurements (up to $\sim$1%) with 10-30 hours of observations, an accuracy that can rival with other arrays of Cherenkov telescopes, despite the smaller collecting area of a single ASTRI telescope.

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The Contribution of the Medium-Sized Telescopes of the Northern Site of the Cherenkov Telescope Array Observatory to Stellar Intensity Interferometry

Jonathan Biteau & Quentin Luce

Université Paris Saclay, IN2P3, France

The revival of stellar intensity interferometry (SII) with HESS, MAGIC and VERITAS, the current generation of imaging atmospheric Cherenkov telescopes (IACTs), has reopened a window on sub-milliarcsecond optical astronomy. This technique, used over distances of O(100 m) between telescopes, enables stellar radii of a few hundred microarcseconds to be measured with a ~10% resolution, assuming disk-like emission. The next generation of IACTs, the Cherenkov Telescope Array Observatory (CTAO), is following this path and has implemented an SII observing system in the camera of the first large-sized telescope at the CTAO-North site. The larger the baselines, the better the angular resolution of the SII measurements. Thus, the addition of the medium-sized telescopes (MSTs) to SII observations at the CTAO-North site will improve angular resolution by a factor ~4 with distances between two telescopes of O(1 km). In this talk, we present the program underway to equip the NectarCAM camera of the MSTs at the CTAO-North site with an SII observing system. We also showcase the improvements in the constraints of disk-like and limb-darkened stellar extensions expected to be achieved using all the telescopes at the CTAO-North site, which will fully open a window left ajar half a century ago.

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Time Table

Program

	Monday	Tuesday	Wednesday	Thursday	Friday
8:45 - 9:00		*Introduction*	J. Cortina & A. Cifuentes	W. Guerin, O. Lai & R. Kaiser	I. Zadeh
9:00 - 9:30		P. Tuthill			
9:30 - 10:00			A. Zmija & N. Vogel		L. Zampieri, M. Fiori & A. Spolon
10:00 - 10:30		M. Lisa		E. de Almeida	
10:30 - 11:00		*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:00 - 11:30		A. Nomerotski & S. Kulkov	D. Kieda & J. Rose	J.-P. Berger	J. Biteau & Q. Luce
11:30 - 12:00				N. Forget & F. Gudin	*Closing remarks*
12:00 - 12:30		P. Saha	C. Carlile		
12:30 - 13:00		*Lunch*	*Lunch*	*Lunch*	*Lunch*
13:00 - 13:30					
13:30 - 14:00					
14:00 - 14:30		Discussions	Discussions **Boat tour** (TBC) Other activities	Discussions	
14:30 - 15:00					***Departure:*** *- 14:30: Boat* *- 15:00: Bus departure* *- 17:00: Arrival at Nice*
15:00 - 15:30	***Arrival:*** *- 15:00: Bus departure at Nice* *- 17:00: Boat to Porquerolles*				
15:30 - 16:00					
16:00 - 16:30					
16:30 - 17:00		*Coffee Break*		*Coffee Break*	
17:00 - 17:30		J. Monnier		N. Cvetojevic	
17:30 - 18:00					
18:00 - 18:30		S. Karl & V. Leopold		R. Walter	
18:30 - 19:00					
19:00 - 19:30	*Dinner*	*Dinner*	*Dinner*	*Dinner*	
19:30 - 20:00					
20:00 - 20:30					
20:30 - 21:00					