Workshop on Hanbury Brown & Twiss interferometry: Detailed program

Overview

Monday May 12th 2014

Time	*Place*	
08:15	Hotel Kyriad	Bus departs to Observatoire
8:30 - 9:00	“La Nef” at observatoire	Welcome
9:00 - 9:45	“La Nef” at observatoire	Talks
9:45 - 10:30	“La Nef” at observatoire	Coffee break
10:30 - 12:30	“La Nef” at observatoire	Talks
12:45 - 14:00	Restaurant at observatoire	Lunch
14:30 - 16:00	“La Nef” at observatoire	Talks
16:00 - 16:45	“La Nef” at observatoire	Coffee break
16:45 - 18:00	“La Nef” at observatoire	Talks
18:15	“La Nef” at observatoire	Bus departs to Hotel Kyriad
19:30	Restaurant ”La Vigna”	Workshop dinner

Tuesday May 13th 2014

Time	*Place*	
08:15	Hotel Kyriad	Bus departs to Observatoire
9:00 - 9:45	“La Nef” at observatoire	Talks
9:45 - 10:30	“La Nef” at observatoire	Coffee break
10:30 - 12:30	“La Nef” at observatoire	Talks
12:45 - 14:00	Restaurant at observatoire	Lunch
13:45 - 14:30	Restaurant at observatoire	(Optional) “Grande Coupole” visit
14:30 - 16:15	“La Nef” at observatoire	Talks
16:15 - 17:00	“La Nef” at observatoire	Coffee break
17:00 - 18:00	“La Nef” at observatoire	Talks
18:00	“La Nef” at observatoire	Closing remarks by F. Vakili
18:15	“La Nef” at observatoire	Bus departs to Hotel Kyriad

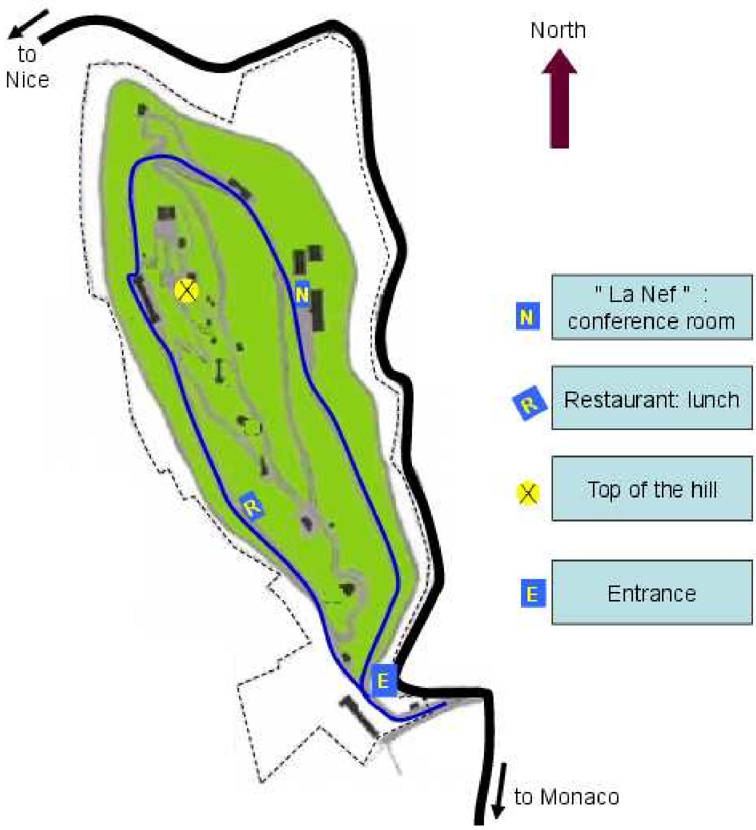

Figure 1: Map of the observatory.

Detailed program

Monday May 12^{th} 2014

8:30 - 9:00	Welcome	
Chair:	M. Lintz	
9:00 - 9:45	S. Tanzilli	HBT type measurements in quantum optics experiments
9:45 - 10:30	*Coffee break*	
10:30 - 11:15	C. Westbrook,	The Hanbury Brown Twiss effect for matter waves
11:15 - 12:00	W. Guerin,	A random laser with cold atoms
12:00 - 12:30	T. Peng Kian,	Measuring Temporal Photon Bunching from a Blackbody
12:45 - 14:30	*Lunch*	
Chair:	R. Kaiser	
14:30 - 15:00	G.L. Lippi,	Current issues in coherence for small laser sources
15:00 - 15:30	A. Kellerer,	Towards quantum telescopes: Can Quantum Optics serve astronomy?
15:30 - 16:00	V. Malvimat,	Towards higher-order HBT astronomical interferometry
16:00 - 16:45	*Coffee break*	
16:45 - 17:15	T. Wentz,	Feasibility of obtaining phase information using three-point HBT
17:15 - 18:00	D. Strekalov,	Intensity interferometry for imaging dark objects

Tuesday May 13^{th} 2014

Chair:	P. Nuñez	
9:00 - 9:45	E. Ribak,	Long-baseline Intensity Interferometry
9:45 - 10:30	*Coffee break*	
10:30 - 11:15	D. Dravins,	Astronomical Imaging a Thousand Times Sharper than Hubble
11:15 - 11:45	T. Lagadec,	Reviving Stellar Intensity Interferometry with CTA
11:45 - 12:30	D. Kieda,	Stellar Intensity Interferometry (SII) Development at StarBase-Utah
12:45 - 14:30	*Lunch*	
Chair:	TBD	
14:30 - 15:00	P.D. Nuñez,	Capabilities of Future Intensity Interferometers
15:00 - 15:45	E. Horch,	Intensity Interferometry with SPAD Detectors at SCS University
15:45 - 16:15	A. Okumura,	Optical Systems for the Cherenkov Telescope Array
16:15 - 17:00	*Coffee break*	
17:00 - 17:30	G. Rodeghiero,	Intensity Interferometry with the ASTRI/CTA mini array
17:30 - 18:00	N. Smith,	Intensity Interferometry with single photon avalanche photodiodes
18:00 - 18:10	F. Vakili	Closing remarks

Abstracts

Astronomical Imaging a Thousand Times Sharper than Hubble: Optical Interferometry with the Cherenkov Telescope Array

Dainis Dravins
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Much of the progress in astronomy is led by improved imaging. In the optical, one tantalizing threshold will be two-dimensional imaging of stellar surfaces. With typical sizes of a few milliarcseconds, bright stars require interferometry over kilometer-long baselines. Although several concepts for such interferometer complexes on the ground and in space have been proposed, their realization is not imminent.

However, the availability of large optical flux collectors (air Cherenkov telescopes, in particular CTA the Cherenkov Telescope Array primarily erected for gamma-ray studies) enable a revival of the quantum-optical method of intensity interferometry, once developed for astronomy but recently mainly pursued as boson- or HBT-interferometry in high-energy particle physics.

The advantage of intensity interferometry is that it is insensitive to either atmospheric turbulence or to telescope optical imperfections, enabling very long baselines as well as observing at short optical wavelengths. Telescopes are connected only electronically (rather than optically), and the noise budget relates to electronic timescales of perhaps 10 nanoseconds (light-travel distances of meters), enabling the use of also optically imperfect telescopes.

CTA will cover an area of a few km^2, and with suitable software could already quite soon become the first kilometer-scale optical imager, reaching into novel microarcsecond parameter domains. It could reveal the surfaces of rotationally flattened stars with their circumstellar disks and winds, monitor a nova eruption, or possibly even visualize an exoplanet during its transit across some nearby star.

References: Stellar Intensity Interferometry: Prospects for sub-milliarcsecond optical imaging, New Astronomy Reviews 56, 143-167 (2012); http://dx.doi.org/10.1016/j.newar.2012.06.001 ; preprint: http://arxiv.org/abs/1207.0808 ; Optical Intensity Interferometry with the Cherenkov Telescope Array, Astropart.Phys. 43, 331-347 (2013); http://dx.doi.org/10.1016/j.astropartphys.2012.04.017

A random laser with cold atoms

William Guerin
INLN, France

A standard laser is built upon two basic ingredients: an amplifying medium and an optical cavity. The cavity aims at trapping the photons so that they go through the gain medium many times. A random laser is a laser without cavity, where the photon-trapping effect is provided by multiple scattering in the gain medium itself. I will present the realization of such a random laser in a cold atom vapor. I will first show that the two necessary ingredients, gain and multiple scattering, can be easily obtained separately. I will then discuss the issue of combining them simultaneously, which is a much harder task. I will finally present our recent experimental observations, which show a signature of random lasing in a cold-atom cloud.

Intensity Interferometry with SPAD Detectors at Southern Connecticut State University

Elliott Horch
Southern Connecticut State University, New Haven, CT USA

Single Photon Avalanche Diode (SPAD) detectors offer excellent timing capabilities for photon counting timing correlation studies such as intensity interferometry, though with the price of substantial dead time. However, SPAD arrays are now being fabricated that come in a variety of small formats, with the possibility of larger formats just a couple of years away. This may help mitigate the effect of dead time and make the devices a viable way to conduct astronomical observations using intensity interferometry. In this talk, work to date with a two-channel system that has been assembled for ultra-high resolution astronomical measurements will be described. An observing program at Lowell Observatory will be discussed, as well as a design concept for a new multi-aperture system using SPAD arrays. Such a system would in principle allow for the imaging of stellar surfaces at important blue wavelengths as well as for exquisite precision in binary star orbit and mass determinations, among other scientific projects.

Towards quantum telescopes Can Quantum Optics serve astronomy?

Aglaé Kellerer
Durham University

Today's telescopes still rely on the classic processes of light diffraction and interference. But this will change and intensity interferometry, developed by Hanburry-Brown and Twiss, can already be cited as an exception. Since intensity interferometry was first proposed in the 1960s, quantum optics has made substantial progress and the future of astronomy may well depend on the use of novel quantum optical mechanisms.

As the challenges associated with building ever larger telescopes increase, processes such as stimulated emission, quantum entanglement and quantum non-demolition measurements will offer possibilities well worth to be explored. I will examine the possibility of overcoming the diffraction limit of a telescope through photon cloning processes heralded by trigger signals (http://dx.doi.org/10.1051/0004-6361/201322665). The feasibility of the proposed scheme is still uncertain, but as the technology advances and new ideas come forward the set-up may be sufficiently expanded and modified to become practicable.

The main message of this talk will be the possibility in principle to improve the angular resolution of a telescope beyond the diffraction limit, and thus to achieve high-angular resolutions even with moderately sized telescopes. The intention is to motivate a broad discussion that includes similar and perhaps more viable approaches.

Stellar Intensity Interferometry (SII) Development at the StarBase-Utah Observatory

D. Kieda, S. Lebohec, N. Matthews N. Traeden, J. Skowronek,
University of Utah Department of Physics and Astronomy, Salt Lake City, Utah USA

The University of Utah is using a pair of 3-m diameter segmented optical telescopes at StarBase-Utah as a development testbed for future SII instrumentation that can be deployed at large arrays of Imaging Atmospheric Cherenkov Telescopes (IACTs) such as VERITAS and CTA. The telescopes use photomultiplier tubes (PMTs) on the focal plane to detect starlight. The PMT signals are passed through an analog optical fiber system to a central signal digitization system that employs four continuously digitizing (250 Mhz/channel) flash analog-to digital converters (FADCs). The data from the FADCs is processed by a Virtex-5 FPGA and recorded to a fast streaming (12 TB) disk for digital filtering and cross-telescope correlation. During Spring 2014, we began our first observation using these telescopes. In this talk, I will describe the Starbase-Utah telescopes and instrumentation, and describe initial performance and science results from these new observations.

Reviving Stellar Intensity Interferometry with Cherenkov Telescope Arrays: Laboratory simulation of stellar observations

Tiphaine Lagadec & Dainis Dravins
Lund Observatory, Lund, Sweden

Stellar surface imaging requires telescopes connected over kilometers, feasible through intensity interferometry. It requires arrays of telescopes which are coming into existence from another field, the study of gamma rays through Cherenkov light in air. The largest current project is CTA, the Cherenkov Telescope Array, foreseen to have some 70 telescopes spread over a few square km, proposed to be used also for stellar intensity interferometry.

We report here on the first experimental simulations of stellar intensity interferometry with a CTA-like array. Over a 25-meter distance in an optical laboratory, artificial stars (round and elliptical, single and binary) are measured by a group of telescopes equipped with nanosecond-resolving photon-counting detectors. Their stream of pulses feeds into real-time digital correlators with ns resolution, computing cross correlations between the (quantum-optically random) intensity fluctuations measured in different pairs of telescopes. Numerous pairs of telescopes at different baseline lengths and orientations fill in the interferometric (u,v)-plane. The measured signals give information on the nature of the source (size, asymmetry, etc.) and provide a two-dimensional map of its second-order spatial coherence, from which theoretical models predict that full images can be extracted.

Experimental challenges have included the illumination for the artificial stars. In particular, signal-to-noise in intensity interferometry depends on the intrinsic brightness temperature of the source (e.g., Hanbury Brown & Twiss could measure the hot star Rigel but not the cool star Betelgeuse, despite their equal apparent brightness). The same constraints apply to laboratory sources: tungsten filaments in incandescent lamps reach about 3,000 K and high-pressure xenon arcs perhaps 6,000 K, either of which is much cooler than desired temperatures of 10,000 K or more. Since intensity interferometry is based on intensity fluctuations in thermal (Gaussian) light, use of a laser is not an option since laser light is second-order coherent with no fluctuations in either time or space.

Artificial starlight is produced by dynamical light scattering of laser light in a small volume of a liquid with microscopic particles. These undergo thermal (Brownian) motion, scattering and broadening the laser line, and producing a thermal light source of very narrow spectral width but with a conveniently high brightness temperature. Since the signal-to-noise ratio in intensity interferometry in principle does not depend on the spectral passband, this enables a reasonably realistic simulation.

The experience from such experiments will serve as input for specifying the instrumentation and observing procedures to be used on future full-scale observations with (in particular) CTA, the Cherenkov Telescope Array, aiming at order-of-magnitude improvements of the angular resolution realized in optical astronomy.

Current issues in coherence for small laser sources

Gian Luca Lippi
INLN, France

The question of coherence of laser radiation and its investigation was vigourously studied in the first decade of the existence of lasers. By the inception of the second decade most of its fundamentals had been clarified and have been since considered as given. However, the downsizing of lasers, down to cavity volumes of the order of a few modes of the electromagnetic field, has opened new questions about the coherence of their radiation. In this contribution, I will present a summary of the state of the art of the questions which are asked, the current knowledge about their answers, the ensuing implications and the open problems. The solution to these questions extend beyond the physics of lasers to cover the more general field of coherence with a limited number of available modes.

Towards higher-order HBT astronomical interferometry

Vinay Malvimat[1], *Olaf Wucknitz*[2]
[1]*Indian Institute of Technologys,* [2]*Max-Planck-Institut fuer Radioastronomie*

The new generation of intensity interferometers now designed, raises the possibility of measuring intensity correlations with three or more detectors. Quantum optics predicts two interesting features in many-detector HBT: (i) the signal contains spatial information about the source (such as the bispectrum) not present in standard HBT and (ii) correlation increases combinatorially with the number of detectors. The challenge, however, is obtaining sufficient signal to noise.

We consider signal-to-noise ratio (SNR) limitations for classical two-element and multi-element HBT and find that the fundamental parameter is the number of photons detected per coherence time. A simple approximate formula is derived for thermal sources. The SNR can be improved by going to lower frequencies (Rayleigh-Jeans regime) or by using many detectors. However, in these cases the SNR is limited not by shot noise but by another manifestion of HBT, whose classical form is well know in radio-astronomy as wave noise. In this regime larger collecting areas does not help, the only way to improve the sensitivity is to increase the number of samples.
related publication:

Vinay Malvimat, Olaf Wucknitz, Prasenjit Saha Intensity interferometry with more than two detectors? MNRAS 437 (2014), 798 http://adsabs.harvard.edu/abs/2014MNRAS.437..798M

Capabilities of Future Intensity Interferometers

Paul D. Nuñez
Collège de France & Laboratoire Lagrange

There has been a recent interest in reviving astronomical intensity interferometry due to the construction of large arrays of gamma-ray telescopes (e.g. CTA). Aside from sensitivity issues, an important challenge is to reconstruct stellar surface images since the Fourier phase information is not available from two-point intensity correlations. Previous simulation efforts have provided evidence that stellar surface imaging is possible with two-point correlations. It has also been shown that phase information is contained in higher order correlations, namely three-point correlations. While higher correlation measurements have a lower signal-to-noise ratio, they will allow us to reconstruct images by using tools that have been developed for amplitude interferometry. In this talk I will present ongoing simulation efforts for reconstructing images from two- and three-point correlation data. I will focus particularly on the data simulation and analysis of an (Achernar-type) *Be* star.

Optical Systems for the Cherenkov Telescope Array
Akira Okumura
University of Leicester, UK

The Cherenkov Telescope Array (CTA) is the next-generation ground-based gamma-ray observatory which detects very-high-energy (VHE) gamma rays in the energy band of a few tens of GeV to a few hundreds of TeV. In order to increase the effective area and to achieve lower energy threshold for VHE gamma-ray observations compared to the current telescopes, about 50 to 100 optical telescopes with large primary mirrors (4 to 23 meters in diameters) will be built in northern and southern sites. The large number of telescopes distributed over 3 km^2 have an excellent potential to use CTA as an intensity interferometer which would have the highest angular resolution of 100 micro arcseconds. In this talk, we introduce several types of optical systems to be used in CTA. Some relevant technologies: light guides, mirrors, photodetectors and front-end electronics are also covered.

Measuring Temporal Photon Bunching from a Blackbody
Tan Peng Kian
National University of Singapore

We developed an experimental setup to resolve the temporal photon bunching from a blackbody. This is achieved by projecting the thermal photons from the light source into a single Gaussian transverse mode and also a linear polarization plane. The photons are then spectrally filtered by a series of diffraction grating monochromator and etalon into 2 picometers bandwidth, thus increasing its coherence time from 10 femtoseconds to 0.5 nanoseconds, which is longer than our photon detectors' temporal jitter of 40 picoseconds. This setup is demonstrated by measuring the two-photon timing coincidences from the Sun for 45 minutes, and explicitly observing the predicted Lorentzian structure of temporal photon bunching.

Utilizing Hanbury Brown and Twiss Interferometry to Directly Observe Black Hole Accretion Disks and Exoplanets
Genady Pilyavsky , Dr. Philip Mauskopf , Nathan Smith , Ed Schroeder , and Ian Chute
Arizona State University

Poster presentation: Photon correlation interferometry (Hanbury Brown and Twist Interferometry) has several advantages over traditional Michelson interferometry at optical/near-infrared (NIR) wavelengths, including the ability to measure visibilities from telescopes separated at very large distances at the cost of instantaneous sensitivity. This enables a unique capability to make measurements of sources that are both compact and highly luminous.

We explore the possibility of using photon correlation (HBT) interferometry in the optical/NearInfrared (NIR) to directly observe the accretion disk around systems such as Cygnus X-1, a binary system with an O giant star and a Black Hole candidate. We also discuss the potential to observe and resolve super-massive black holes in nearby quasars at visible wavelengths. Additionally, we examine the possibility of resolving star systems containing exoplanets such as hot Jupiters in the NIR. We address the current complications with obtaining an exoplanet spectra and how an array of telescopes utilizing HBT measurements can overcome them. Lastly, we will discuss data acquisition and analysis, what is possible with the current technology and what can we expect to achieve in the future as our instruments continue to improve.

Long-baseline intensity interferometry: data transmission and correlation
Erez Ribak
Technion, Israel

We wish to extend stellar intensity interferometry where amplitude interferometry is limited. First we would like to go to kilometric baselines because of the independence from nanometric optical path demands. While this can be done on the ground, the way to overcome atmospheric opacity (especially in the ultraviolet) is to go to space, employing separate spacecraft for multiple baselines. We are constructing a three-station correlator in the lab to be deployed on three moving platforms on an air-table. In parallel, we deal with the bandwidth issue of transmitting losslessly signals from remote stations to the central correlator.

Intensity Interferometry with the ASTRI/CTA mini array

Gabriele Rodeghiero for the ASTRI collaboration, C.Barbieri, G. Naletto

In the framework of the CTA Observatory, the INAF-led ASTRI Project intends to deploy a mini-array (4 to 7 units) of SST-2M telescopes in the Southern site envisaged for the array construction. The ASTRI/ CTA mini-array will provide a unique opportunity for the CTA early science phase. In addition to the gamma ray observations, the mini-array could be used as the first kilometer-scale array for Intensity Interferometry investigations. The presentation will discuss the perspectives of Intensity Interferometry with the ASTRI/CTA mini-array, estimating the sensitivity of the system and the possible technical solutions related to the telescope design. The number of mini-array units will allow an unprecedented U-V plane coverage and the exploration of many angular scales. In addition, the ASTRI/CTA mini-array proposes a new concept of data handling among the telescopes based on off-line correlation of the signals, that leads to a more detailed and flexible analysis with respect to real time systems.

Photon Counting Terahertz Interferometry

H. Matsuo, J-R Gao, A Tartari et al.J-R Gao, A Tartari et al.
Advanced Technology Center, National Astronomical Observatory of Japan

Poster presentation: Photon counting technology in terahertz frequency region will open a new field in astronomy that used photon statistics as an observational tool. Electromagnetic wave has been treated as either stream of independent photons in shorter wavelengths or as radio wave in longer wavelengths. However in far-infrared wavelengths or terahertz frequencies, both characteristics of the photon and the wave appear. Photons in this wavelength region are usually bunched, whose photon statistics tell us the physical states of emission sources, such as thermodynamic temperature when the source is in equilibrium. When one make use of the bunched photon measurements on two telescopes, one can measure their intensity correlation, as demonstrated by the Hanbury-Brown and Twiss (HBT) experiment for the intensity interferometry. Photon counting detectors would further improve the interferometer technology and realize high sensitivity aperture synthesis interferometry for future space programs, which can be named as Photon Counting Terahertz Interferometry (PCTI). The technology is based on the intensity correlation which is the same as in HBT, and by using fast photon counting detector, it would be possible to achieve high time resolution better than one wavelength passing, which can be used as the phase information of intensity fluctuation. Furthermore, the element telescopes can be independent and number of elements is not limited and very long baseline interferometry could be realized. Detector technology based on superconducting tunnel junction detector is proposed. Their fast quantum response to terahertz photons enables wide bandwidth measurements to be used to obtain the phase information of the intensity fluctuation. Series connected junctions coupled with high-impedance and low noise amplifiers can be use to count each photon signal with enough signal-to-noise ratio when leakage current of junction is less than an order of pico-ampere. With the ultimate sensitivity under low-background condition in space, PCTI would image a few hundred Kelvin sources with micro-arcseconds angular resolution using baseline length of several thousand kilometers in far-infrared wavelengths.

References

1. H. Matsuo, Requirements on Photon Counting Detectors for Terahertz Interferometry, Journal of Low Temperature Physics 167, pp. 840845 (2012).
2. H. Matsuo, Fast and High Dynamic Range Imaging with Superconducting Tunnel Junction Detec-

tors, Journal of Low Temperature Physics, (2014), DOI 10.1007/s10909-013-1022-3

Intensity Interferometry with single photon avalanche photodiodes

N. Smith, P. Mauskopf, I. Chute, G. Pilyavsky, E. Schroeder
Arizona State University

We describe measurements of intensity correlations from bright stars using two small commercial telescopes equipped with commercial fiber-coupled silicon avalanche photodiode single photon detectors. The photon coincidence rate as a function of time delay is measured with a commercial frequency counter with a resolution of 20 picoseconds and the detectors have a timing resolution of 600 picoseconds. Based on these measurements, we calculate that is should be possible to measure the angular diameters of M-dwarfs in a relatively short integration time with an array of commercial telescopes. These measurements would be useful for better understanding the physics of these stars and in some cases, better constraining the diameters of their companion exoplanets.

Intensity interferometry for imaging dark objects

Dmitry V. Strekalov,
Jet Propulsion Laboratory

A dark object placed between a thermal light source and an observer affects not only the visible intensity distribution (by producing a shadow), but also the intensity correlation function. In Astronomy, the shadow may often be unsuitable for retrieving any information regarding the objects structure and optical properties, while such information encoded in the correlation function may still be available. We study the possibilities for recovering this information, and in particular imaging the objects by mapping optical column-density for absorbing objects, and phase-gradient for phase objects. In this talk I will show examples of numerically generated correlation functions for typical lab as well as interstellar geometries and demonstrate the image recovery using modified Gerchberg-Saxton approach.

HBT type measurements in quantum optics experiments

Sebastien Tanzilli
LPMC Université Nice Sophia Antipolis

Quantum opticians usually employ and exploit genuine or modified HBT setups as standard tools for characterizing non-classical states of light. One the one hand, HBT measurements permit to characterize the emission statistics of photonic modes that are, depending on the emitter and on the spatial and spectral features, thermal, poissonnian, sub-poissonnian, or deterministic. On the other hand, auto-correlation and cross-correlation functions, recorded in the single photon counting regime, permit to infer the unique properties of single photon and two photons sources, that are further utilized in quantum communication applications. For instance, when applied to a single photon source, a genuine HBT setup helps qualifying the uniqueness emission feature. Moreover, when applied to a two photon source, a modified HBT setup permits measuring simultaneous emission time correlations, as well as single photon coherence time. During this talk, I will review some situations in which HBT type setups and related measurements are exploited in and for quantum optics or communication experiments.

Feasibility of obtaining phase information using three-point HBT

Tina Wentz and Prasenjit Saha
Physik Institut, University of Zurich

Standard HBT measures the spatial power spectrum of a source, but not the corresponding phase. This limitation could be overcome by three-point HBT, which yields the spatial bispectrum. But the demands for photon counts are greater than in standard HBT. This work assesses the feasibility of measuring the bispectrum for the brightest stars. A possible application would be imaging the possibly time-varying features in the atmosphere of Betelgeuse, that have been reported from classical interferometry. Our results indicate that three-point HBT could accomplish this with of order 100 square metres of collecting area.

The Hanbury Brown Twiss effect for matter waves

C. I. Westbrook
Laboratoire Charles Fabry de l'Institut d'Optique

In spite of the predilections of the authors, the work of Hanbury Brown and Twiss on intensity interferometry may have had a more powerful impact on quantum optics than on astronomy. That it could have such an impact on quantum optics is even more surprising when one considers that the their results are more easily explained in the context of classical optics than quantum optics. Nevertheless for more than 50 years, quantum optics has been inspired by intensity interferometry and continue to add new variations and insights. I will discuss experiments using cold atoms, both bosons and fermions, and from sources both coherent and incoherent. The observations yield useful information concerning what happens in atomic systems both when they interact with each other and when they interact with light.

Intensity correlations in Superradiant scattering from cold atoms *C. I. Westbrook*
Laboratoire Charles Fabry de l'Institut d'Optique

Poster presentation: We have measured the 2nd order coherence, or 2-body correlations, of atoms from a Bose–Einstein condensate participating in a superradiance process. We compare the statistics of the superradiant phenomenon with the ordinary spontaneous emission and with a stimulated emission from a Bose–Einstein condensate. Despite strong amplified emission the correlation properties of the superradiance are close to those of ordinary spontaneous emission, that is the radiation resembles a thermal state.

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