Workshop ADONI 2018

Orvieto - Palazzo dei Sette
16-18 Maggio 2018

Sommario delle presentazioni

LABORATORIO NAZIONALE
ADONI
OTTICA ADATTIVA

Mercoledì 16 Maggio

Recent developments on optical turbulence forecast I

Alessio Turchi *(INAF-OA Arcetri), Gianluca Martelloni, Elena Masciadri*

In this contribution we present a selection of the most recent results obtained by the Optical Turbulence group in Arcetri in the field of the forecast of optical turbulence and atmospheric parameters, applied to ground-based astronomy. We show, specifically, the progress of the ALTA project, created as an operational instrument to support observations at the Large Binocular Telescope (LBT). With respect to the results shown at LBT User Meeting (June 2017), we refined the numerical model calibration for the forecast of the astroclimatic parameters (seeing theta, tau), reaching excellent performances. This is also due to the large nights sample (102) used as a reference and to the new calibration procedure. Thanks to the performance optimization of the whole system we are now able to run with initializations computed at a more recent time, and thus more accurate, with a gain of 12 hours. We provide a detailed analysis of the ability of our operational system in forecasting the precipitable water vapor with excellent results observed in reconstructing an episode of exceptionally low PWV at Paranal. Finally, we present recent published results aiming to validate wind speed measurements obtained with the MCAO system GeMS using as a reference our WS estimates obtained with Meso-Nh.

MAORY : the Adaptive Module for ELT

Paolo Ciliegi *(INAF-OAS Bologna)*

The Multi Conjugate Adaptive Optics RelaY (MAORY) is the adaptive optics module for the European Extremely Large Telescope (ELT). MAORY is one of the ELT first light instruments approved for construction and it must provide, from the beginning of its operations, a multi-conjugate (MCAO) and a single conjugate compensation mode (SCAO). The MAORY Consortium is composed by six INAF institutes in Italy and by the IPAG institute in France. In this talk I will present the status of the MAORY project.

SHARK-NIR @LBT Status update

Maria Bergomi *(INAF-OA Padova)*

SHARK-NIR is one of the two coronagraphic instruments proposed for the Large Binocular Telescope. Together with SHARK-VIS (performing coronagraphic imaging in the visible domain), it will offer the possibility to do binocular observations combining direct imaging, coronagraphic imaging and coronagraphic low resolution spectroscopy in a wide wavelength domain, going from 0.5µm to 1.7µm. Additionally, the contemporary usage of LMIRCam, the coronagraphic LBTI NIR camera, working from K to L band, will extend even more the covered wavelength range. We will report the final design of the SHARK-NIR instrument and the overall status of the project, currently in its subsystem integration and testing phase and whose technical first-light is foreseen in 2020.

Mercoledì 16 Maggio

Scientific Return from Arcetri’s AO systems

Enrico Pinna *(INAF–OA Arcetri), Lorenzo Busoni, Alfio Puglisi, Fabio Rossi, Guido Agapito, Marco Bonaglia, Roberto Speziali, Vincenzo Testa, Adriana Gargiulo, Felice Cusano, Rossi Andrea, Roberta Carini, Simone Esposito*

I will overview the astrphysical results obtained by the AO systems developed at INAF-OAA. Then I will show the AO facilities currently made available at LBT for the INAF community. The goal is to stimulate the interest of the observers and boost a synergic collaboration with the technological community in the ADONI’s framework.

May Mice help scientists to develop a Smart Wave Front Sensor?

Massimiliano Mattioli *(INAF OA-Roma), Fernando Pedichini, Marco Stangalini, Simone Antoniucci, Gianluca Li Causi, Roberto Piazzesi, Vincenzo Testa*

The worldwide used PC Mouse has inside it the technology to become a powerful element in the development of large format Shack-Hartmann wavefront sensors for night and day time use. Indeed, its small smart camera, used to detect differential movements of the device and to drive the PC pointer, may be employed as a basic tile for the building of a sensing cell for the acquisition of the centroid movement of stars or extended objects. In this work we present preliminary results, from laboratory experiments, that provide a first assessment of the capabilities of a smart wavefront sensor based upon such off-the-shelf and cost-effective technology

SHARK-VIS project status update

Massimiliano Mattioli *(INAF OA-Roma), Fernando Pedichini, Marco Stangalini, Simone Antoniucci, Gianluca Li Causi, Roberto Piazzesi, Vincenzo Testa*

Shark-VIS is the high-contrast high-resolution imager at LBT. About six months after the instrument successfully passed its final design review we describe the status of the project. The latest issued design, critical issues and milestones achieved will be shown along with the progress made in setting up the r&d laboratory used also as a test bench for the instrument.

A testing facility for AO on-sky demonstrations at the Copernico Telescope

Simonetta Chinellato *(INAF - OA Padova)*

A testing facility for AO instrumentation will soon be available at the Coudé focus of the Copernico 182cm telescope located in Asiago. Conceived within the ADONI laboratories, the facility will be accessible to all the AO community for on-sky direct testing of multi-purpose visiting instrumentation. We will show the refurbishment at the telescope for the activation of the new focal station and the current status of the laboratory hosting facility.

The application of MCP detector to Adaptive Optics: Large Wave Front Sensing and Virtual Adaptive Optics (VAO) in the visible band

Marco Landoni *(INAF-OA Brera), Stefano Covino, Giovanni Pareschi, Enrico Pinna, Michela Uslenghi, Roberto Ragazzoni*

The availability of reloaded versions of Multi Channel Plate (MCP) detectors, whose main features are the absence of readout (RON) noise with fast frame-rate and large format, allow us to explore their application in the field of Adaptive Optics (AO). We illustrate the characteristics, performances and current limitations of these detectors (widely used already in spaceborne applications) emphasizing their deployment in two main-stream problems in AO. The first is related to apply these large Field-of-View detectors to Wave Front Sensing for Extremely large aperture telescopes (e.g. MAORY). Current AO systems, when applied to ELTs, suffer from the limited size of CCD detectors for wavefront sensing, especially when combined with low-RON noise requirements. A second possible future application is the post-facto reconstruction to diffraction limited imaging by adapting Holographic Technique algorithms whose has been already successfully demonstrated in this task at ESO-VLT with NACO for bright objects. The main limitation of these techniques comes from the RON limited regime of frames when faint targets are observed. The possibility to use MCP detectors could allow to mitigate the problem and recover AO-comparable images in the visible band.

Giovedì 17 Maggio

SOUL project status

Fabio Rossi *(INAF-OA Arcetri), Enrico Pinna, Simone Esposito, Philip Hinz, Alfio Puglisi, Guido Agapito, Runa Antonio Briguglio Pellegrino, Marco Bonaglia, Tommaso Mazzoni, Luca Carbonaro, Marco Xompero, Armando Ricciardi, Manny Montoya, Oli Durney*

SOUL is the upgrade of the SCAO systems of the LBT. At ADONI 2016 we introduced the project, today we report about its progress and current status. After a forced standby in 2017, the first LBTI wavefront sensor has been successfully upgraded last March and will be soon integrated at the telescope for closed loop testing. In June we will go on with the first FLAO wavefront sensor and in September we will start the on-sky commissioning.

Ingot - Wave Front Sensor for ELT elongated Sodium LGS

Simone Di Filippo *(Univ. Roma Tre, INAF-OA Padova)*

We present a revised version of z-invariant class Wave Front sensor for Sodium LGS fired aside the telescope aperture for the new Extremely Large Telescope. In this case, a spatial dependance occurs on the focal plane, which is linked to the height where the resonant scattering occurs. By examining the basic parameters of the WFS geometry, we proposed a new solution which includes both refractive and reflection approaches. We then present the new optical design and some preliminary signal simulations of the so called “Ingot WFS”.

A special niche for high-contrast imaging observations: shadows cast on circumbinary discs

Valentina D’Orazi *(INAF-OA Padova), Raffaele Gratton*

High-contrast imaging observations have started to open a breach on previously unexplored astrophysical issues, related to a variety of different objects, from exoplanets to circumstellar discs and jets. In this talk I will present our recent results from SPHERE observations of V4046 Sgr, a 20-Myr old close binary system known to host an unexpectedly circumbinary gas-rich disc. We have discovered the presence of shadows in the disc, interpreted as related to the central binary, and exploited them to measure disc flaring and geometrical distance of the system. This is the first time that such a measurement (independent on disc modelling) is carried out and it opens the way to investigate similar systems with the same technique. The SHARK-NIR facility will be able to provide similar powerful tools to investigate this topic, complementing SPHERE for the Northern hemisphere sample. A general presentation of all the science that will be addressed with SHARK-NIR will be also presented.

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Optobiology: biological matter as adaptive optical element

Pietro Ferraro *(CNR - ISASI)*

It will be illustrated how biological elements, like live bacteria species and Red Blood Cells (RBCs) can accomplish optical functionalities. Suspended RBCs are demonstrated to behave as tunable liquid micro-lenses, whose focus is controllable changing the chemistry of the liquid buffer. Imaging properties of biological cell will be analyses. This capability is demonstrated through dynamic wavefront characterization and direct imaging, thus opening new scenarios in biophotonics for endoscopic vision and diagnostics. In particular, it will be shown that by considering live cells as optical elements allows to introduce a new paradigm in biomedical diagnosis for blood disease and for launching new strategies for detecting circulating tumor cells (CTC) in Lab-on-Chip microfluidic devices.

Calibrazione interna di strumenti adattivi: dalla ERIS-CU al MAORYCUA

M. Dolci *(INAF-OA Abruzzo), G. Di Rico, I. Di Antonio, A. Valentini, A. Di Cianno, A. Riccardi, D. Ferruzzi, S. Esposito*

La Calibration Unit (CU) è un sottosistema di ERIS progettato congiuntamente dai gruppi ADONI di Teramo e Arcetri, attualmente in fase di assembly, integration & verification. Parallelamente a queste attività, l'esperienza finora acquisita in questo campo è stata utilizzata per affrontare una nuova sfida: la progettazione del Calibration Units Assembly (CUA) di MAORY. Nella presentazione vengono mostrate le caratteristiche della ERIS-CU ed i problemi affrontati durante la progettazione, nonché quelli legati alla realizzazione di alcuni componenti critici. Si fornisce quindi una breve descrizione del lavoro di analisi che si sta iniziando a condurre per la progettazione del MAORY-CUA.

Characterization of QSO host galaxies with AO imaging

Simona Paiano *(INAF-OA Padova), Renato Falomo*

After more than 50 years since the discovery of quasars the role of the powerful nuclear activity in the centers of massive galaxies is still little understood. However, the discovery that virtually all massive galaxies host an inactive super massive black hole (BH) in their centers indicate that an important link is in place between the processes of formation of galaxies and the presence of their massive BHs. Therefore, the study of QSO galaxies offers the opportunity to investigate the relation between BHs and their host galaxies over the cosmic time. Because of the faintness of the signal from the host galaxies and their small size (at $z > 1$ the host galaxy signal is at radii < 0.3-0.5 arcsec) both high sensitivity and superb resolution (narrow PSF with "depressed" wings) are mandatory for this kind of study. This can be achived either by space-based observatories (HST, JWST) or using ground-based telescopes with imagers assisted by AO modules. We evaluate the future capabilities of EELT+MICADO to characterize high redshift QSO host galaxies through detailed simulations.

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LINC-NIRVANA status update: MCAO first light

Luca Marafatto *(INAF-OA Padova), Maria Bergomi, Jacopo Farinato, Roberto Ragazzoni, Marco Dima, Carmelo Arcidiacono*

LINC-NIRVANA (LN) is a high resolution, near-infrared imager for the Large Binocular Telescope (LBT). Its imaging capabilities are assisted by a double module of Multi-Conjugate Adaptive Optics - Layer Oriented. When operative, it will be the first MCAO instrument usign solely Natural Guide Stars. We give here an overview of the current status of the instrument, which is in its technical commissioning phase, and the first results from on-sky performance that proved to be very promising as we closed a MCAO loop, reducing the PSF dimension of a star from 0.36 arcsec, without correction, to 0.073 arcsec with MCAO on.

Fast cadence speckle-free high contrast imaging: SFADI and SFI

Gianluca Li Causi *(INAF-IAPS), Marco Stangalini, Simone Antoniucci, Fernando Pedichini, Massimiliano Mattioli, Vincenzo Testa, Roberto Piazzesi*

The Speckle-Free Angular Differential Imaging method (SFADI) is a high-contrast technique that is based on speckles freezing in a kHz sequence of images, which are ADI-combined after speckle identification and suppression in each frame. Such process minimizes the residual background and increases contrast limit wrt classical ADI, and is able to retrieve low contrast extended sources when used in Speckle-Free Imaging mode (SFI), a variant also capable of high contrast quick look in few seconds and field-tracked high contrast imaging. We present here the concept, and the current research and implementation status.

Sistemi MCAO: stima delle prestazioni e copertura del cielo

Guido Agapito *(INAF–OA Arcetri), Cedric Plantet, Lorenzo Busoni, Simone Esposito*

Arcetri è coinvolta in due importanti progetti di ottica adattiva multi-coniugata: MAORY e MAVIS. MAORY, il multi-conjugate Adaptive Optics RelaY è il più grande sistema di Ottica Adattiva in sviluppo in Italia e si prefigge un ambizioso obiettivo: uno SR in banda K del 50% sul campo di vista di 53x53” della Multi-AO Imaging Camera for Deep Observations (MICADO) e sul 50% del cielo. MAVIS, l’MCAO Assisted Visible Imager and Spectrograph è invece una proposta per uno strumento per l’Adaptive Optics Facitlity di ESO al VLT, che dovrebbe essere composto da un modulo di ottica adattiva multi-coniugata e da una camera per immagini più uno spettrografo che operano nelle bande visibili dello spettro elettromagnetico. Un importante lavoro di stima delle prestazioni e di copertura del cielo è stato fatto finora dal nostro gruppo per offrire un valido supporto allo disegno di questi strumenti. Presenteremo qui i risultati preliminari e soprattutto gli strumenti usati per effettuare queste stime.

Giovedì 17 Maggio

Adaptive optics systems to tackle aberrations in advanced gravitational wave interferometric detectors

Lorenzo Aiello *(GSSI), Elisabetta Cesarini, Viviana Fafone, Matteo Lorenzini, Yury Minenkov, Ilaria Nardecchia, Alessio Rocchi, Valeria Sequino*

The detections of the gravitational waves with the LIGO-Virgo experiments opened a new era in the investigation of the universe. The sensitivity of these experiments from few hundred Hz up is limited by the shot noise, that can be reduced by increasing the laser power circulating in the interferometer. However, optical power absorptions in the substrate and coatings of the test masses induce both an increase of the optical path length in the substrates of the mirrors (thermal lens) and a thermal expansion of the optic itself along the optical axis (thermo-elastic deformation). These effects reduce the performances of the detector and its sensitivity. An adaptive correction system (TCS, Thermal Compensation System) is then needed to mitigate the optical aberrations and allow proper interferometer operation. In this talk the design and performances of the adaptive correction system of Advanced Virgo will be presented, with a discussion on its possible evolution for next generation detectors.

Quantifying the capabilities of MAVIS for selected science cases

Elisa Portaluri *(INAF-OA Padova), Renato Falomo, Roberto Ragazzoni, Simona Paiano, Valentina Viotto, Davide Greggio, Demetrio Magrin, Jacopo Farinato, Daniela Fantinel, Michela Uslenghi, Marco Gullieuszik*

We are investigating the capabilities of MCAO optical observations (λλ 0.4 – 0.8 μm), with an 8-m telescope assessing the feasibility of selected science cases. We plan to build a set of plausible PSFs for MAVIS and use our Advanced Exposure Time Calculator (http://aetc.oapd.inaf.it/) to produce simulated images of targets. In particular, we are interested in the characterization of the UV properties of active and inactive galaxies up to redshift 1. This will yield the opportunity to compare the present knowledge (e.g. GALEX, HST, …) in the UV of the galaxies in the local Universe with that of galaxies at earlier cosmic epochs. The goal is to understand the astrophysical processes that drove the evolution of star formation and to relate these processes to the building of galaxies.

SCAO science in the visible: what to expect from SHARK-VIS

Simone Antoniucci *(INAF - OA Roma), Fernando Pedichini, Massimiliano Mattioli, Marco Stangalini, Simone Antoniucci, Gianluca Li Causi, Roberto Piazzesi, Vincenzo Testa*

With the upcoming first light of SHARK-VIS in 2019, it is now time to analyse in detail the main scientific cases we will be able to tackle with this instrument and to highlight the breakthrough results we aim to obtain, based on the expected performance provided by the unique fast-cadence approach of SHARK-VIS. The expected SHARK-VIS scientific contributions will also be put in context with what can be obtained with other already existing SCAO facilities operating in the visible (e.g. SPHERE/ZIMPOL, VisAO).

SHARK-NIR: performance coronografiche dello strumento

Elena Carolo *(INAF–OA Padova), Daniele Vassallo, Jacopo Farinato, SHARK-NIR Team*

SHARK-NIR e' l'imager coronografico nel vicino infrarosso per il Large Binocular Telescope in Arizona. L'imaging diretto e' vincolato dal limite della regione ad alto contrasto del coronografo, ma questa non è l'unica restrizione per la scoperta e la caratterizzazione dell'oggetto osservato vicino alla stella; per ottenere le prestazioni nominali del sistema ottico è necessario un solido controllo del fronte d'onda. Per questo motivo è richiesto un sistema ottico adattivo estremo. Inoltre, gli algoritmi di riduzione delle immagini non sono affidabili a piccole separazioni, quindi è richiesta una post elaborazione dei dati affidabile e ben calibrata. L'analisi effettuata sui dati simulati per SHARK-NIR ha permesso di ottenere un post processing a diverse condizioni atmosferiche di seeing e magnitudine dell'oggetto osservato, per alcuni dei coronagrafi più utilizzati, come funzione della separazione dalla stella ospite per ottimizzare la scoperta dei pianeti extrasolari. Saranno presentati i risultati delle performace dello strumento nella sua configurazione finale, a diverse condizioni di Strehl, utilizzando il codice ottimizzato per la riduzione delle immagini simulate.

Post-processing in AO high-contrast imaging: a statistical approach

Marco Stangalini *(INAF-OA Roma)*

The recent availability of very high frame rate (kHz) adaptive optics data offers a unique opportunity for the application of advanced and statistical post-processing techniques for contrast enhancement and image restoration. In this contribution we will present preliminary results obtained from the application of such techniques on the SHARK-VIS forerunner data at visible wavelengths. In more detail, we will show how a new method of non-linear time series analysis, the recurrence quantification analysis (RQA), can be employed as a statistical discrimination technique in the detection of faint sources in astronomical imaging.

AO observation of microlensing events

Vincenzo Testa (*INAF-OA Roma), Achille A. Nucita, Domenico Licchelli, Simone Antoniucci, Fernando Pedichini, Gianluca Li Causi, Roberto Piazzesi, Marco Stangalini, Massimiliano Mattioli, Francesco De Paolis, Gabriele Ingrosso, Francesco Strafella*

Microlensing events may reveal exoplanetary systems acting as lenses, that are usually discovered by light curve analysis. This method often results in model parameters affected by degeneracy that can be solved via parallax, high resolution imaging, astrometric measurements and the like. AO observations of events with a bright lensed star would allow degeneracy removal or reduction as well as detection of the two sources. Here we present the case of Feynman-1 and discuss how we can apply AO techniques to systems like this to achieve our goals.

Sub-arcsec measurements of the pyramid face angles

Runa Antonio Briguglio Pellegrino *(INAF-OA Arcetri), Enrico Pinna*

In a pyramid WFS, the positioning of the four pupil images on the detector depends on the pyramid face angles. In order to achieve a positioning accuracy lower than 1/10 of subaperture, the pyramid faces shall be all manufactured to the same angle with great accuracy. Testing specifications come in turn more demanding, so that a sub-arcsec precision is requested, against tens of arcsec alignment and repeatability errors of the test bench. We present a new technique for the measurement of the face angle difference, based on the sequential interferometer sampling of the pyramid base and face. We discuss the measurement modeling, the laboratory setup with the calibration of the rotation stage and the measurement performed on the GMT pyramid prototype.

Recent developments on optical turbulence forecast II

Gianluca Martelloni *(INAF OA Arcetri, INSTM), Alessio Turchi, Elena Masciadri*

In this contribution we present a selection of the most recent results obtained by the Optical Turbulence group in Arcetri in the field of the forecast of optical turbulence and atmospheric parameters, applied to ground-based astronomy. We focus our presentation on preliminary results obtained two on-going studies. From one side we investigate the possibility to implement auto-regression, Kalman filter and neural network methods to improve the model forecasts on a time scale of a few hours (the most interesting from the perspective of the flexible scheduling). We present preliminary results obtained above a rich statistical sample of night above Mt.Graham and Cerro Paranal. On the other side we investigate the possibility to predict the optical turbulence and the atmospheric parameters also on the day time conditions characterized by a different turbulent regimes (convective regime). This should open to the possibility to apply our technique to solar telescopes such as EST and non astronomical but challenging contexts such as, for example, satellite telecommunications.

Impact of Adaptive Optics correction on phase retrieval using phase diversity

Daniele Vassallo *(INAF-OA Padova)*

Phase diversity is a focal plane wavefront sensing technique that allows to retrieve the phase aberration introduced by a camera starting from two images of whatever object, one of which (the diverse image) is intentionally corrupted by a known aberration. If natural light is used (e.g. a star), then the atmosphere introduces some noise on top of the instrumental aberrations that have to be sensed. Operating in closed-loop is thus mandatory for phase diversity, but still some detrimental effects can be observed, especially in the faint-end regime. We present here the results of a simulation campaign aimed at assessing the impact of residual atmospheric aberrations on the quality of phase retrieval with phase diversity. Instrumental aberrations to be retrieved have been modeled on a realistic error budget of SHARK-NIR, the second-generation high-contrast imager of LBT, while images are generated with the instrument end-to-end Fresnel simulator.

Poster

Venite Adoniamo

Runa Antonio Briguglio Pellegrino *(INAF-OA Arcetri)*

Il network ADONI potrebbe essere un ottimo meccanismo per rendere più efficiente il nostro lavoro attraverso la collaborazione trasversale. Allo stato attuale, purtroppo, tale collaborazione non è supportata da strumenti centralizzati e in qualche modo "ufficiali". In questo poster dal sapore propositiv-polemico e di chiaro stampo positivista, abbiamo provato a elencare una serie di possibili strumenti con cui ADONI potrebbe rendere più snella la collaborazione al suo interno e si renda più visibile all'esterno. L'idea è che si tratti di attività "inerziali", dove cioè dopo un piccolo sforzo iniziale le cose vadano avanti da sole su base personale. Una buona parte del poster è bianca per raccogliere suggerimenti, adesioni e disponibilità.

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