Astrofisica di frontiera con l'ottica adattiva italiana

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Book of Abstracts

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A new software for photometry and astrometry in the AO era

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In the AO era, the intrinsic complexity and variability of the point spread function (PSF) poses severe challenges to the analysis of optical and NIR images.
I will present preliminary results from a new astro-photometric software which we specifically designed to deal with spatially complex and variable PSFs.
The software iteratively build a series of numerical PSFs from different regions of the image, interpolates them and fits them it to identified stellar sources, improving at each step both the PSF modelling and the source fitting quality.
I will present the main advantages and disadvantages of this software and compare its performance to that of classical softwares (like DAOPHOT) on synthetic and real images.
Potential synergy with classical PSF-reconstruction methods will be also discussed.

Sistema solare / 44

AO assisted spectropolarimetry to study the formation of penumbra in sunspot

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During their lifetimes, sunspots show several dynamic phenomena whose underlying physical processes still need to be clarified. For example, the formation process of the penumbra remains unclear because of the need for long time-series of high-resolution observations that are hardly acquired with present-day telescopes. We report the results derived from analysis of unique observations carried out with the Interferometric Bidimensional Spectrometer (IBIS) and high-order adaptive optics system, which pointed to a new scenario for the formation of the penumbra in sunspots.

Analisi dati: sfide e strumenti / 10

AO data analysis challenge

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Adaptive Optics correction retrieves PSF temporally and spatially variating following the optical turbulence dynamics. The stability of the energy ratio core/wings affect the photometric precision, and the spatial variation of the shape of the PSF core makes complicated the morphology analysis of quasi point-like sources. Time averaging mitigates the temporal variation effect while spatial variation needs proper characterization. Current AO/MCAO facilities (e.g., LUCI-FLAO, SPHERE, GEMS) routinely produce valuable high-resolution data, which exploitation represents a challenge

for existing data reduction tools. Today we will focus on the challenges and on the solutions currently adopted to mitigate the complexities, looking forward to PSF-reconstruction and PSF-fitting techniques.

Extragalattico pt.2 / **29**

AO observations of AGNs: from the present to ERIS and MAVIS

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Despite the limitations in terms of sky coverage and corrections, current AO facilities are providing a unique, high spatial resolution view of AGNs and their hosts. After presenting some examples of the results obtained, I will discuss the unsolved issues that will be tackled by the advent of the new generation IR and optical AO fed Integral Field Spectrographs, ERIS and MAVIS at VLT.

Formazione stellare ed esopianeti pt.2 / **26**

AO-assisted integral-field and long slit spectroscopy: investigating brown dwarfs and exoplanets

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In this contribution I will present and discuss the exploitation of AO-assisted
spectroscopic instrumentation (both integral field and long-slit) in order to detect and characterise exoplanet and brown dwarf population.
Fundamental information on mass, separation, age, surface gravity and clouds (more in general atmospheric properties) can be inferred via this kind of observations, overcoming degeneracies that plague photometry. This has significant impact on our understanding of formation and evolution mechanisms for sub-stellar objects, still debated.

Popolazioni stellari / **5**

AO-assisted spectroscopy in crowded stellar fields: present and future science opportunities

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In this talk I will discuss state-of-the art scientific use and future perspectives of integral field spectroscopy assisted by adaptive optics as an optimal multi-object capability in dense stellar fields.

Popolazioni stellari / **37**

An in-depth view on bulge globular clusters in the MCAO era.

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MCAO are a cornerstone technology for current and future telescopes (g.e. ELT). The synergy between high-resolution near-infrared imagers and MCAO systems is already leading the way for the characterisation of the stellar content and the structural properties of all of those systems in the Galaxy for which optical observations are almost totally useless. I will give an overview of the results recently achieved for highly obscured globular clusters in the Milky Way bulge thanks to the MCAO system GeMS at the Gemini South Telescope. These results clearly demonstrate that, once both the photometric and astrometric performances of these systems are fully constrained (in terms of variable PSF, geometric distortions), then high-quality proper motion measurements entirely based on ground-based AO observations can be performed. This is going to be one of the major achievements of the AO community in stellar clusters studies.

Extragalattico pt.2 / **36**

Compact quiescent galaxies with adaptive optics

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Relic galaxies, low-redshift old compact massive galaxies, are thought to be local counterparts of red and quiescent compact massive galaxies at high-z (the so called "red nuggets"), that missed the channels of galaxy size growth and evolved undisturbed since their first mass assembly. Therefore, they represent the perfect laboratories to study the mass assembly in the early universe through the cosmic history. Thanks to wide-sky multi-band deep photometric surveys and low-resolution spectroscopic follow-ups, a large sample of photometrically selected and spectroscopically validated ultra-compact massive galaxies at z < 0.5, consisting of small (Re < 1.5 kpc) and massive (M_star > 8*10^10 M_solar) systems, has been collected (e.g. KiDS@VST; Tortora et al. 2018). Future instruments (as Euclid) will allow to increase this redshift baseline, discovering large samples of compact quiescent galaxies, progenitors of the local biggest galaxies or relics, up to redshift z = 1.5 and beyond. Due to the sub-arcsec and sub-PSF nature of such galaxies (since Re < 0.4 arcsec), adaptive optics technique is the only way to resolve them in both photometry and spectroscopy. I will discuss the possible use of the upcoming ERIS and MAVIS spectrographs, the perfect instruments for this kind of analysis. The spatial resolution reached by these instruments can first allow to derive very precise estimates of the structural parameters. Moreover, they provide a unique opportunity to study their stellar populations and constrain the IMF from the very central galaxy regions to the peripheries. In this way, we can constrain the physical scenario which led to the formation of such

very peculiar objects, determining constraints on the accretion history of the most massive galaxies in the Universe till the present day.

Popolazioni stellari / 14

Deep into the core of dense star clusters with ELT

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We discuss some science cases that will exploit the Extremely Large Telescope (ELT) diffraction limit power. We focus on a novel and detailed analysis of a young star cluster in the Large Magellanic cloud, R136–like. The main aim of this study is to quantify precision and accuracy of stellar proper motions measurements in crowded field when using an ELT working at its diffraction limit. This can serve as a reference study for future development of ELT scientific cases. In particular we investigate our future ability to detect the dynamical signature of intermediate-mass black holes with mass ~10^4M⊠ through detailed measurements of stellar proper motions.
Finally, using a similar approach, we will explore another natural science target for astrometric measurements with ELT: the Galactic centre Arches'cluster.

Fromazione stellare ed esopianeti pt.1 / 38

Demographics of Exoplanets in Wide Orbits: A Multi-Technique Approach

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The combination of transit surveys and radial-velocity programs has revolutionized our understanding of planets orbiting close to their host stars and our understanding of exoplanetary systems in general. However, a detailed comprehension of the orbital and physical properties and frequencies of extrasolar planets at orbital separations beyond that of Jupiter in the Solar System, and how they relate to the fundamental characteristics of their parent stars (what we call wide-orbit exoplanet demographics), is still missing. This gap in our understanding must be filled in order to provide a complete picture of the complex processes of planet formation evolution. We will discuss the prospects for joint analyses of results from multiple methods and obstacles that could hinder such analyses, with a particular emphasis on the combination of ground-based high-contrast imaging observations and Gaia high-precision space-based astrometry.

Fromazione stellare ed esopianeti pt.1 / 25

Detection and characterization of very young planets

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I will briefly discuss how detect and characterize very young planets. This requires to select the right targets and to use a multi-wavelength approach. I will illustrate the key observations using a few examples.

Popolazioni stellari / 31

ERIS at VLT as a stepping stone for next generation AO assisted IFS

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We plan to discuss a few medium resolution near infrared spectral features that can be used to contrain metallicity distribution of old (RR Lyrae, Type II Cepheids) and young (Classical Cepheids) stellar tracers in crowded and highly reddened regions of the Galactic inter bulge and of the Galactic thin disk. In particular, we will focus our attention on the key opportunity to couple NIR/MIR photometry and spectroscopy.

The italian way to AO / 19

ERIS: the new 1-5µm Adaptive Optics Instrument extending and enhancing imaging and spectroscopy capabilities for VLT

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The Enhanced Resolution Imager and Spectrograph (ERIS) is the new Adaptive Optics (AO) instrument for the VLT aiming to replace NACO and SINFONI. Its development is led by a Consortium of Max-Planck Institut fuer Extraterrestrische Physik (MPE), UK Astronomy Technology Centre, ETH Zurich, Leiden University, European Southern Observatory (ESO) and Istituto Nazionale di Astrofisica (INAF). ERIS will host a new high-resolution coronagraphic camera (NIX) ranging from 1 to 5 microns and SPIFFIER, a refurbishment of the Integral Field Unit spectrograph currently installed in SINFONI, covering J, H and K bands. ERIS will be installed at the Cassegrain focus of the VLT UT4, which is also hosting the Adaptive Optics Facility (AOF) sharing with ERIS the 1170-actuator Deformable Secondary Mirror and the Sodium Laser Facility. The ERIS AO system is developed by INAF with ESO's collaboration, and provides a Natural Guide Star (NGS) mode to deliver high contrast correction and a Laser Guide Star (LGS) mode to extend high Strehl performance to large sky coverage, enabling observations from exoplanets to high redshift galaxies. INAF responsibility in ERIS project is not only limited on AO, but it is also extended to the supply of the on-board Calibration Unit (CU) and the leading of the Instrument Software development.
The ERIS structure is currently in Arcetr where the AO module and the CU have been integrated.

AO module successfully passed the Acceptance in December 2019 and it is going to be shipped to MPE early February 2020 for the integration of NIX and SPIFFIER, before running the ESO formal acceptance process in Europe as a whole instrument, enabling the shipment to Paranal.
This contribution describes the instrument concept, outlines its expected AO performance, the related operational modes, and highlights where it will be mostly competitive.

Sistema solare / 45

EST MCAO: ongoing activities

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The European Solar Telescope (EST) will provide spectro-polarimetric measurements of the solar atmosphere with unprecedented sensitivity and accuracy within one arcminute field of view. To this purpose, its optical scheme, as well as its MCAO system, are designed to minimize the instrumental polarization. We report on ongoing activities related to the EST MCAO, which include further design studies, realization of a prototype system, numerical simulations, and lab tests.

Fromazione stellare ed esopianeti pt.1 / 18

Exoplanets with AO instruments

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The exoplanet science has received great benefit from the availability of AO instrumentation, especially with the building of the last generation of extreme AO systems. I this talk I summarize the main scientific results achieved in the last years with the direct imaging techniques, the perspectives for planet detection and characterization with future instrumentation, and the synergies with other planet detecion techniques.

Analisi dati: sfide e strumenti / 30

Exploiting post-AO fast-cadence high-contrast imaging data in the visible

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Diffraction-limited frames sequences, containing millions of pupil-stabilized images acquired at kHz rate after Extreme Adaptive Optics (ExAO) correction, will be the baseline outcome of SHARK-VIS, the forthcoming high-contrast imager in the visible band for the Large Binocular Telescope (LBT). Such fast-cadence imaging concept allows us to freeze the evolution of the ExAO residual speckles,

opening the possibility to fully exploit the temporal information within the data and improve high-resolution and high-contrast performances.
In the framework of the SHARK-VIS pipeline, we will present the results of real on-sky acquisitions at LBT, by showing the processing flows of some standard algorithms and of the novel methods we are developing, capable of pushing the contrast to the noise limit and the resolution to the theoretical diffraction.

Extragalattico pt.2 / **9**

Exploring the distant Universe with AO at the focus of cosmic telescopes

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Gravitational lensing is allowing us to access physical scales and luminosities in the distant Universe with unprecedented accuracy, offering the opportunity to infer key physical quantities otherwise unaccessible without AO. While such scientific programs are somehow propaedeutic, AO technology coupled with cosmic telescopes will project astronomers into a new territory. I'll present what we are learning from the current studies on lensed and super-lensed fields, focusing on the exploration of the farthest and faintest galaxies, down to the parsec scale, eventually catching the still elusive formation of globular clusters, potential agents of cosmic reionization.

Analisi dati: sfide e strumenti / **34**

From the white paper to the dark sky: quantifying the capabilities of the next-generation telescopes using simulations

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Modern astronomy is strongly supported by the considerable development of the technology: the effort towards probing new AO methods, building new instrumentation and systems is tightly correlated to the progress in science. The next generation of telescopes have to demonstrate to be up to the task, meeting the expectations of the astronomical community. This can be partially ensured conducing preliminary simulations to quantify their capability, usually selecting some key science cases presented in white books as science drivers. In this talk I will discuss how close-to-real simulations can serve as a tool to help the complex interaction of data construction. They also go simultaneously with the definition of some characteristics of the instrument itself, being one of the most efficient way to validate scientific proposals, flow down requirements into quality of the data products, or means for the solution of technical trade-off processes. In particular, I will refer to my experience in the context of the ELT+MAORY and MAVIS projects.

Extragalattico pt.1 / **4**

Galaxies at high resolution: what ERIS and MAVIS can do for us

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The incoming AO imagers and spectrographs ERIS and MAVIS for ESO/VLT are specifically designed to maximize sky coverage, in particular to allow for extragalactic studies. ERIS will cover the near-IR bands starting from early 2021, MAVIS will observe in the optical from ~2025. I will discuss what are the cutting-edge questions that these instruments will contribute to answer, and what are the synergies with JWST and, later, with E-ELT

Extragalattico pt.2 / **27**

Galaxy evolution and environment: lessons from MUSE and perspectives with MAVIS

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Environmental effects play a primary role in galaxy evolution and in particular in shaping the star formation history of galaxies in groups and even more so in dense environments.

The MUSE IFU has allowed to study in detail how environmental effects act in shaping galaxy properties, its limitation being essentially the spatial resolution that can be reached using ground-based instrumentation. Similarly, the physical properties of galaxies and of their star forming clumps can be studied only out to small distances before being hampered by the seeing effects. The advent of AO assisted instrumentation, such as MAVIS at VLT, will allow to overcome this difficulty, leading to a huge step forward in the comprehension of how galaxy evolve in different environments.

In this talk I will present what we have learned in this field thanks to the GASP MUSE survey and how we propose to use MAVIS to shed light on the open questions.

Popolazioni stellari / **16**

High resolution imaging in crowded stellar fields: present and future science

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Ground-based imagers assisted by Multi Conjugate Adaptive Optics (MCAO) systems are the technological frontier to obtain high-quality stellar photometry and astrometry in crowded fields at the highest possible spatial resolution. I will review the main scientific results obtained in the last years in the field of stellar populations by using AO data and key advancements in their exploitation. I will also discuss future challenges and perspectives at the edge of a new golden-era that will soon open thanks to the availability of imagers assisted by MCAO systems at 30-40m class-telescopes and their complementarity with JWST from the space.

Extragalattico pt.1 / **8**

High resolution multiwavelength diagnostics of AGN and their host galaxies

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TBD

Analisi dati: sfide e strumenti / **35**

INAF Computing Facility: DATA-STAR (IT evolution from 'project e-infra' to 'INAF e-infra')

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The activities related to the INAF IT had a heavy acceleration in the last year, also related to the infrastructure of the Bologna Tecnopole, the assignment of the CINECA-led Euro HPC project, the SKA and CTA projects. This acceleration has made that the experience gained with national calculation, storage and archives projects (eg MoU CINECA, CHIPP project, connection with the Commercial Cloud, IA2 archives, etc.) should evolve towards the creation of an e-infra INAF. This must meet the request of the community by taking advantage of the opportunities that large projects are giving us and using, through strong coordination, the skills present in INAF. The **DATA-STAR** INAF e-infra is not only an hardware statement, but the key main value is the people networking.
We therefore want to inform the community of the steps that are being taken in this direction, illustrate the idea and organization of this strong coordination, and collect the community's advice and requests.

Formazione stellare ed esopianeti pt.2 / **43**

Looking for binary planets, satellites and disks around exoplanets

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In the past decades the exoplanets hunting has improved so much that thousands of planets have been confirmed and partially characterized. Both indirect and direct detecting techniques have filled this huge sample, from the terrestrial to the gas giant and brown dwarf regime. One further step would be to detect exomoons and disks/rings around exoplanets, that we expect to be there taking as a model our Solar System. We will show how this goal is, however, a really challenging one and which estimates we can obtain from the present instrument and data. In particular, we developed a technique based on the PSF subtraction to deeply investigate the neighborhoods of exoplanets detected with the direct imaging technique in order to look for further companions and circumplanetary disks.

The italian way to AO / 11

MAORY - MICADO : the winning combination for next generation diffraction limited observations

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MAORY is the Adaptive Optics Module for the European Extremely Large Telescope (ELT). Coupled with MICADO, the high resolution camera, will enalble the ELT to perform diffraction limited near infrared observations. I will describe the MAORY project and I will illustrate the scientific drivers of the MAORY-MICADO combination.

The italian way to AO / 6

MAVIS: a Visible MCAO-equipped imager and spectrograph for the VLT

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MAVIS is a multi-conjugate adaptive optics (MCAO) equipped system, designed to be coupled with the Very Large Telescope (VLT) Adaptive Optics Facility, with the aim to deliver visible images and integral field spectrograph data with 2-3x better angular resolution than the Hubble Space Telescope. The imager will deliver diffraction-limited image quality in the V band, in a 30"x30"field of view, with imaging from U to z bands and possibly exploiting fast cadence acquisition on a sub-section of the field. The current spectrograph baseline includes a selectable field-of-view of 2.5"x3.6", or 5" x7.2", with a spatial sampling of 25 or 50 mas respectively. This combination can deliver a spectral resolving power of R=5,000 to R=15,000, covering a wavelength range from 380 - 950 nm. The project is currently in its Phase-A study, which is being carried on by a consortium, led by Australian's AAO, and with a fundamental contribution by INAF, which is responsible for the Adaptive Optics Module design and is involved in the MAVIS science team.

Popolazioni stellari / 22

MAVIS: a revolution in the study of resolved stellar population in the nearby Universe

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The formation and evolution of galaxies, and in particular of the Milky Way, is one of the major puzzles of astrophysics: a detailed physical scenario is still missing, and its understanding requires the joint effort of observations and theories. The evolution with time of the chemical content of a galaxy is one of the topic constraints to understand the most relevant mechanisms driving galactic formation and evolution. Star clusters have proven to be excellent tracers of the chemical evolution of our Galaxy,as done in the last years by the Gaia-ESO Survey.
The challenge is now to move towards nearby galaxies and to investigate, with comparable precision, the star cluster populations in different environments.
MAVIS is the instrument that will make a revolution in studies of crowded field populations, as star clusters, in nearby galaxies. I will shown some science cases that will benefit of the MAVIS AO and spectroscopic facilities.

Extragalattico pt.2 / 28

Passive galaxy candidates in the early Universe

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The selection of passive galaxies in the early (z>3) Universe is very challenging, and crucial to constrain theoretical modelling of the processes responsible for their rapid assembly and abrupt shutdown of the star formation. I will describe the careful selection method which we developed to single out quiescent galaxies at high z in the CANDELS fields. I will present the resulting sample of 102 candidates at z>3 and show how ALMA archival observations support and confirm their passive nature. Finally, I will discuss the contribution of adaptive optics in the study of early passive galaxies.

Sistema solare / 13

Picturing the solar system small bodies with new-generation adaptive-optics systems

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Information about solar system small bodies' size, shape and surface structures is crucial to shed light on the mechanisms behind planetary accretion and evolution.
Until very recently, a detailed characterization of such properties could be obtained only for the handful of objects visited by space missions.
However, new-generation adaptive-optics instruments can open a new frontier in planetary sciences, allowing ground-based disk-resolved investigation of a much greater, statistically significant, number of small bodies.
I will review the state-of-the-art of this field and discuss its perspectives, especially in view of the upcoming availability of advanced instruments of special interest for the Italian community.

Formazione stellare ed esopianeti pt.2 / 32

Planet formation, from ALMA to ERIS

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In the last years, ALMA has revolutionised the field of plant formation.
The high angular resolution campaigns are showing a great variety of protoplanetary disk morphologies, revealing the presence of rings, gaps, cavities and spirals.
Such sub-structures suggest the presence of young giant planets that perturbs the mass distribution

and dynamics of gas and dust in the disk.
And yet, a direct proof is still missing. Confirming the presence of young giant planets in correspondence of the dust gaps and cavities seen with ALMA is a mandatory step to understand the origin of the disk sub-structures and to shed light on the formation mechanism of (giant) planets.
High contrast imaging is a powerful tool and in particular VLT/ERIS has the great potential to detect newly-born planets (partly) embedded in the
natal disk via inside the disk thanks to the possibility to observe at long wavelengths (L and M).
In my talk, I will present a proposal for an ERIS observing program starting from the ALMA observations of protoplanetary disks.

Formazione stellare ed esopianeti pt.2 / **33**

Planet formation: from SPHERE to ERIS

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In the last years, SPHERE has revolutionized the field of planet formation. Also thanks to Subaru/HiCiao, GPI, and VLT/NACO, the number of protoplanetary disks observed in near-IR scattered light now amounts to more than 100. This census reveals, similarly to ALMA, the high occurrence of disk sub-structures that are likely due to the gravitational interaction with (forming) planets. Yet, the sample is biased toward massive disks around relatively old stars. I will show how our community is alleviating these biases through the SPHERE large programs DARTTS, published, and DESTINYS, ongoing. Also, I will discuss a few specific cases where VLT/ERIS can complement the sample of imaged disks by detecting and characterizing (forming) planets that have remained concealed to SPHERE.

The italian way to AO / **7**

SHARK-NIR: the coronagraphic camera getting ready for the first-light at the LBT

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SHARK-NIR is a coronagraphic instrument conceived to exploit the excellent performance in terms of resolution and contrast of the LBT Adaptive Optics system SOUL. Coupled with its visible counterpart SHARK-VIS, it will offer the possibility to perform 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 M band, will extend even more the covered wavelength range. The main scientific goal of SHARK-NIR is imaging of exoplanets, both for the discovery of new exoplanets and for the characterization of existing ones, however the analysis and study of protoplanetary disks, stellar jets, AGN, QSOs and solar system bodies are within the already foreseen scientific cases of the instrument. We will describe on the final design and actual hardware specifications of the SHARK-NIR instrument and their direct impact of the achievable science. The overall status of the project, currently in its integration and verification phase and whose technical first-light is foreseen by the end of 2020, will be reported.

The italian way to AO / **12**

SHARK-VIS: the new high-contrast optical imager for the LBT

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SHARK-VIS, the forthcoming high-angular-resolution and high-contrast optical (400-900 nm) imager for the LBT, is an INAF PI-instrument (PI Fernando Pedichini) designed and built by the ADONI group of the INAF-Osservatorio Astronomico di Roma. Its first light is foreseen around mid 2020. SHARK-VIS and its near-infrared counterpart SHARK-NIR will take full advantage of the new LBT extreme-AO facility SOUL and will be able to work in synergy also with LBTI/LMIRCAM: this combination will turn LBT into a unique high-resolution facility with continuous wavelength coverage from 0.4 to 3.5 μm.
SHARK-VIS will provide LBT with unprecedented high-contrast imaging capabilities in the visible band, by acquiring diffraction-limited images with angular resolutions down to 15 mas. This will be possible thanks to several technical solutions aimed at optimizing the PSF stability and to the *fast cadence* approach, based on the use of a high-frame-rate low-noise camera and the employ of specific custom algorithms.
We will provide a summary of all the relevant instrument characteristics and will present the observation modes currently available, which are coronagraphic broad- & narrow-band imaging and narrow-band spectral differential imaging. To do this, we will use some realistic setup and observation examples, based on the main scientific programs for the instrument, which include identification of accreting planets in star-forming regions, morphology of jets and disks around young stars, characterization of minor bodies of the solar system, and investigation of the central regions of bright AGNs.

Fromazione stellare ed esopianeti pt.1 / **3**

SPHERE planet imager: instrument presentation and main results

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The SPHERE planet imager is now operating at the VLT since five years.
I will present here a description of the instrument and of its performance. Morover
I will introduce the data reduction methods needed to extract science result from
the instrument data. Finally I will review the main outcome obtained from the instrument in it operativity period.

Analisi dati: sfide e strumenti / **41**

STARFINDER 2.0

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The Starfinder code (Diolaiati et Al 2000) has been the first attempt to face with the typical adaptive optics structured Point Spread Function (PSF) in dense star fields to accomplish astrometric and photometric analysis. The next release of the software will also handle a variation of the PSF across the Field of View (FoV) including the option of an analytical variation model that can be defined by the user. The PSF can be either extracted numerically from the brightest stars in the science field or computed externally and provided as an input in the form of a single image or a cube of images. This feature makes this software suitable to work with PSF models obtained by PSF recostruction techniques.

The italian way to AO / **39**

Science with Adaptive Optics: flavors and constraints

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While it is true that Adaptive Optics cancel out the effects of the atmospheric turbulence in astronomical observations, such simplifying statement carried along a number of possible schemes for the image degradation compensation (sometimes referred to as "flavors") and involves a number of further constraints, the sky coverage being one of the most prominent. I will try to make an overview of the existing and planned techniques, trying to emphasize the areas of possible involvement of the italian astronomy, and to sort out the additional constraints that adaptive optics observations pointing out their effectiveness for telescopes of different apertures.

Sistema solare / **15**

Solar Adaptive Optics

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The solar atmosphere is structured to very small scales which are dynamic in nature. Driven by the quest for higher spatial resolution observations, several AO systems have been deployed at major ground-based solar telescopes during the last two decades. Current high-resolution solar telescopes, which are in the 1-1.5 class, utilise AO routinely to achieve the diffraction limit at visible and NIR wavelengths. Many scientific results have been achieved with the solar AO systems developed so far and new ground breaking knowledge is expected from the operation of the complex AO systems in the coming next generation, 4m class solar telescopes.
The presentation will review the current state of solar AO techniques and their impact on the physical understanding of the fundamental astrophysical processes observed on the Sun.

Analisi dati: sfide e strumenti / **24**

Successful application of PSF-R techniques on SPHERE/ZIMPOL observations of the globular cluster NGC6121

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Precise stellar photometry and astrometry require the best possible modelling of the point spread function (PSF). To date, the best performances have been obtained when building the PSF directly from the image of dense stellar fields, exploiting the fact that each star represents a different realisation of the same PSF. The recent advent of the Adaptive Optics technique makes this method more challenging, because of the strong PSF variations accross the field of view. One alternative is to use PSF-reconstruction techniques, that rely on Adaptive Optics control loop data to determine the shape of the PSF at any spatial location. Despite being theoretically well established, so far PSF-R has never surpassed the performance obtained by standard methods when applied to real astronomical imaging. Here we report on the first successful use of PRIME, a new technique that combines both PSF-R and image fitting, to perform precise photometry and astrometry on real data of the Galactic globular cluster NGC6121, observed with SPHERE/ZIMPOL. Compared to the results obtained using standard techniques, PRIME achieves improvement in precision by up to a factor of four. These results thus pave the way for the exploitation of PSF-R techniques to investigate resolved stellar population science cases with future Adaptive Optics-assisted instrumentation like the Extremely Large Telescopes and MAVIS.

Popolazioni stellari / **42**

The Galactic globular M30 as a laboratory for adaptive optics

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We present optical and NIR photometry for the Galactic globular M30. We focussed our attention on this globular because it is a post core collapsed, this means that the innermost regions display a cusp in density distribution. Moreover, M30 was observed with gound- and space-based (HST) telescopes. In particular, NIR images were collected with both seeing limited NIR array (SOFI@NTT), Ground-layer-adaptive-optics (HAWK-I@VLT) and with different multi-conjugated AO systems (MAD@VLT, GEMS@GEMINI). We present several NIR color-magnitude diagrams and discuss the photometric accuracy and limiting magnitude when moving from seeing limited to AO assisted images. Moreover, we briefly outline the impact on the accuracy of proper motion measurements.

The italian way to AO / **21**

The LBT suite of operational AO instruments

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The Large Binocular Telescope has been conceived as an adaptive telescope, with two deformable secondary mirrors that can serve every gregorian foci and a strong vocation towards the development of state-of-the-art AO instrumentation. The combination of superb wavefront control and 22m baseline binocular capability makes of LBT a yet unrivaled machine, particularly in the field of high angular resolution observations.
Several instruments already in operation at the LBT benefit from AO correction, and more will come in the next years. In this talk, we briefly review the status of the ones currently offered for scientific observations to the italian community.

The LUCIs are two identical NIR spectro-imager with MOS capability with 30" narrow-field and 4' large-field modes assisted by two different AO systems: SOUL, the high-Strehl NGS SCAO system, and ARGOS, the wide-field laser-assisted GLAO system. The LUCIs are installed on both eyes of the LBT capable of full binocular observations and are offered to the italian community as facility instrument through the annual call for proposal.
LINC-NIRVANA is a NIR imager assisted by a twin MCAO system predisposed for interferometric observations. Each MCAO system measures ground and high layer optical turbulence with two NGS multi pyramids WFSs in a layer-oriented configuration and compensate the turbulence using two deformable mirrors. LINC-NIRVANA is under commissioning at LBT and routinely executes MCAO correction achieving peak performances of 20-30% SR in Ks band.
LBTI is the Mid Infrared imager for high-contrast imaging, null-combiner and Fizeau interferometer focused on exoplanets. LBTI completed the NASA's surveys LEECH and HOSTS and it is now offered to the Italian community as an UofA PI instrument.

Analisi dati: sfide e strumenti / 20

The PSF Reconstruction of MICADO@EELT

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MICADO@EELT will be the workhorse facility for Adaptive Optic assisted ground-breaking NIR deep high spatial-resolution imaging and spectroscopy of the next decade. Modern ground-based large telescopes depend heavily on AO systems to correct for atmospheric turbulence. The recovery of the intrinsic properties of the observed sources (position, photometry, morphology) depends critically on the reconstructed point spread function (PSF). Our Team is actively working on developing instrument software for the reconstruction of the PSF of MICADO, independently of the science data, both for single- and multi-conjugate adaptive optics mode observations using AO telemetry data. The PSF-Reconstruction software will be able to generate field-dependent PSF images at the desired wavelength taking into account both AO and non-AO (e.g. telescope or atmospheric)

input. The PSF-Reconstruction service will support the state-of-the-art scientific analysis of the MICADO SCAO-MCAO assisted imaging and spectroscopic data by maximizing the scientific information that could be extracted from complex but powerful AO data.

Formazione stellare ed esopianeti pt.2 / **17**

The role of AO in star formation: a closer look to protoplanetary disks

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Star formation, and in particular formation, evolution and dissipation of protoplanetary disks is a hot topic in nowadays astronomy because it bridges the classic study of star formation to the new discovery and characterization of extrasolar planets.
In this talk I will review the role of AO in star formation, focusing in particular on how our understanding on formation, evolution and dissipation of protoplanetary disks has gained new insight from these observing methods.

Extragalattico pt.2 / **40**

Unveiling the cosmic ray acceleration in SNR using the Balmer emission

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The blast wave of young supernova remnant are often associated with Balmer emission produced by the excitation of neutral Hydrogen in the ISM by shocked ions. The resulting Balmer lines contain information on the shock structure, in particular connected to the plasma temperature, speed, ionization fraction and turbulence level. If the same shock accelerate efficiently cosmic rays (CRs), the shock structure is modified affecting also the associated Balmer emission.
The possibility of study Balmer emission with the high spatial resolution provided by the AO technique can help to understand the physics of collisionless shocks as well as the CR acceleration mechanism, especially because non thermal particles are traditionally studied through X-ray and gamma-rays whose angular resolution is by far worse than optical observations and cannot resolve important details of the shock.