MOEMS-based future systems for ELTs

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Abstract

Studying all types of star clusters at different spatial scales, from Galactic globular clusters, the oldest known objects in the Universe, to young, star-forming, clusters in the Milky Way or in metal-poor galaxies of the local Universe; studying XUV galaxies in spectroscopy and photometry; studying mass distribution of Giant Low Surface Brightness Galaxies; studying kinematics in small galaxies for understanding if the compact ionised gas emission is associated to AGNs, or to individual clumps rather than tracing the global kinematics of these systems; all these Science Cases rely on a high spatial and high spectral resolution instrument in the visible and infrared.
New concepts using breakthrough technologies must be proposed for the next generation of AO systems and instruments in ELTs. MOEMS devices, as large micromirror arrays (MMA), will lead to a new class of compact and efficient systems.

MOEMS Deformable Mirrors (DM) are key components for next generation optical instruments implementing innovative adaptive optics systems, in existing telescopes as well as in the future ELTs. Due to the wide variety of applications, these DMs must perform at room temperature as well as in cryogenic and vacuum environment. We tested the PTT 111 DM from Iris AO: the device could be operated successfully from ambient to 160 K; using our calibration procedure and a specific driving scheme, we obtained a quasi-identical best flat as low as 10nm rms at room temperature and 12nm rms at 160K. We tested also Boston Micromachines continuous DMs at room temperature: due to the accuracy and the repeatability of the electrostatic actuators, we were able to generate a synthetic influence function with a residual as low as 0.4% with respect to the actual influence functions measured for the whole actuation range.

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MOEMS programmable slit mask for astronomical object selection are foreseen in multi-object spectrographs (MOS). We present in this paper the ability of a silicon-based micromirror array to fulfill the performances requested for future MOS instruments in UV-visible-infrared. We are engaged in a European development of tiltable micro-mirror arrays exhibiting remarkable performances in terms of surface quality as well as ability to work at cryogenic temperatures. MMA with 100 x 200 μm2 single-crystal silicon micromirrors were successfully designed, fabricated and tested down to 162 K. In order to fill large focal planes (mosaicing of several chips), we are currently developing large micromirror arrays to be integrated with their electronics.

In future instrumentation, MOEMS DMs (wavefront correction) and tiltable MMAs (for object/field selection) are the key components for correcting/shaping the wavefront/field-of-view at the entrance or within the instruments. We propose new MOEMS-based instrument concepts in order to increase their efficiency and create new observational modes impossible to be implemented with current technologies. BATMAN family of spectro-imagers for current and future telescopes includes the MOEMS disruptive technology.

As a pathfinder, we propose a spectro-imager able to deliver full coverage of a large AO-corrected FOV at high spatial and spectral resolution over a large wavelength band. This spectro-imager design must exploit the exquisite image quality delivered by a Multi Conjugate Adaptive Optics (MCAO) over a large field of view in the visible, i.e. MAVIS on the VLT, delivering a 30"x30" field corrected at 7.5mas/pixel, on a wavelength range from 370 nm to 950 nm. The design of BATMAN@MAVIS, an additional instrument covering science cases and instrument capabilities not covered by the baseline instrument is presented. BATMAN@MAVIS will then allow any part of the FOV to be oriented either towards an imager with the optimum spatial resolution delivered by MAVIS AOM, or towards a spectrograph with high spectral resolution (15 000) divided into 4 sub-bands; the wavelength range could be covered sequentially by changing the grating in the spectrograph. Instrument abilities are wide, including variable spatial bin and variable spectral resolution, as well as any combination of the above modes over the whole FOV. MOS and IFU (scanning slit) are available. Any slit mask configuration could be produced, i.e. any shape, including long slit, and a real time reconfiguration ability. These new features allow new observation strategies for optimizing the recorded scientific data over the FOV, following an optimized strategy on each object. For example, MOS and IFU combination any time and anywhere in the FOV are possible.

Keywords: MOEMS, micromirror array, cryogenic testing, adaptive optics, future generation spectro, imager