Distributed actuator deformable mirror application in visual and ultrafast optics

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Sensorless applications play an important role in adaptive optics development thanks to the reduced hardware complexity. In this technique it is possible to increase image quality or to improve a laser processinfluenced by aberrations through the optimization of a merit function. It has been demonstrated [1] that the image sharpening function based on the optimization of low spatial frequencies depends on the quadratic sum of aberrations coefficients. On this base we realized a deformable mirror modal corrector with the aim of reducing the hardware complexity using as few actuators as possible and reducing the algorithmic complexity. The Modal Deformable Mirror (MDM) is an electrostatic membrane DM where the actuators are composed by a resistive layer which continuously distributes the electrostatic pressure on the membrane. The actuators layout is illustrated in Fig.1(a).

We will show the convenience and the flexibility of use of the MDM by its application in two completely different fields such as visual optics (for the optimization of image quality), and non-linear ultrafast optics (for the optimization of the harmonicsgeneration in gases).

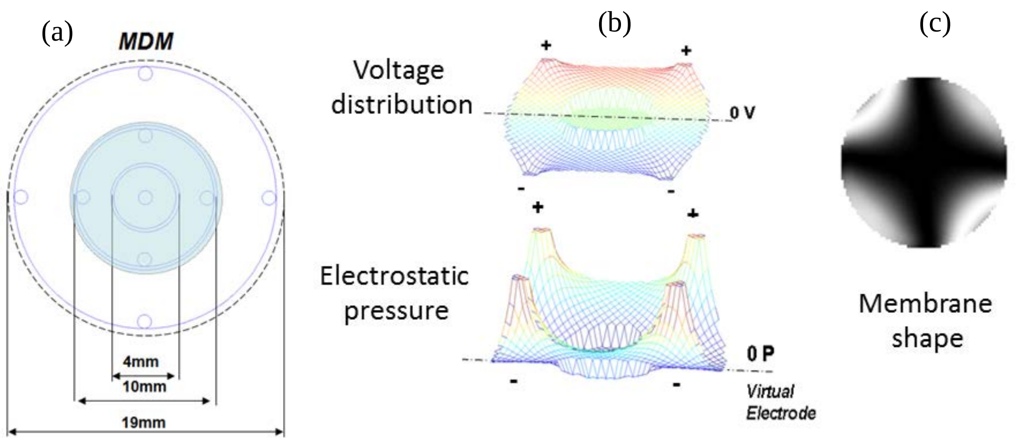

Fig. 1: (a) layout of the electrodes of the MDM;(b) voltage and electrostatic pressure distribution which generates the astigmatism shape illustrated in the interferogram (c).

Fig. 1(b) shows that the application of opposite sign voltage to adjacent contacts generates a sort of virtual electrode, i.e. an area of zero voltage and pressure (see Fig. 1(b), OV and OP dotted lines) which helps in the reduction of the number of actuators hence of the hardware complexity.

We have proventhat, with the use of this device in an image sharpening setup, the image quality can be improved with just about 35 measurements as illustrated if Fig. 2; this is a quite striking result with respect to the slow convergence shown by optimization algorithms.

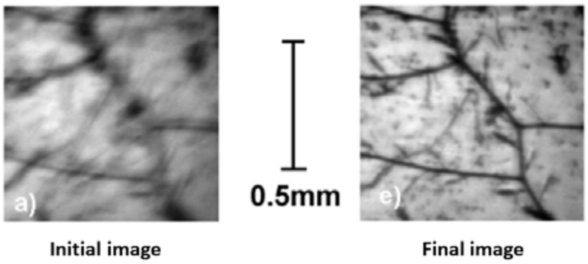

Fig. 2: optimization of an image deteriorated by some aberrations.

We have then demonstrated the extreme flexibility of use of the MDM by applying the same correction to an experiment of ultrafast generation of laserharmonics (HG). In this case a Ti:Sapphirelaser source is used to pump a high-energy Optical Parametric Amplifier (OPA) [3] that provides infrared (IR) tunable pulses in the 1.3-1.8 μm range with duration of about 20 fs and 1-mJ energy level. The IR pulses arefocused in a krypton gas jet for HG; the emitted ultraviolet radiation is then selected by a monochromator; both generation chamber and monochromatorare under vacuum. It is worth noting that HG is sensitive to beam aberrations as well as to the focusing geometry..

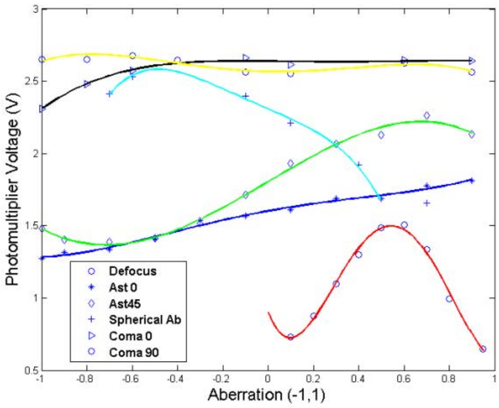

Fig. 3: optimization of the signal detected by the photomultiplier at the exit slit of the monochromator for the 5th harmonic of the IR radiation, tuned to 1.45 μm.

The MDM has been used in front of the experimental chamber to optimize the laser gas interaction. The experimental results (see Fig. 3) show that the optimization of the fifth harmonic of the IR radiation (OPA tuned to 1.45 μm)takes place in a few measurements with and enhancement of the HG yield of about 100%.

References

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3. C.Vozzi, et al, “Millijoule-level phase-stabilized few-optical-cycle infrared parametric source", Opt.Lett.**32**, 2957-2959 (2007)