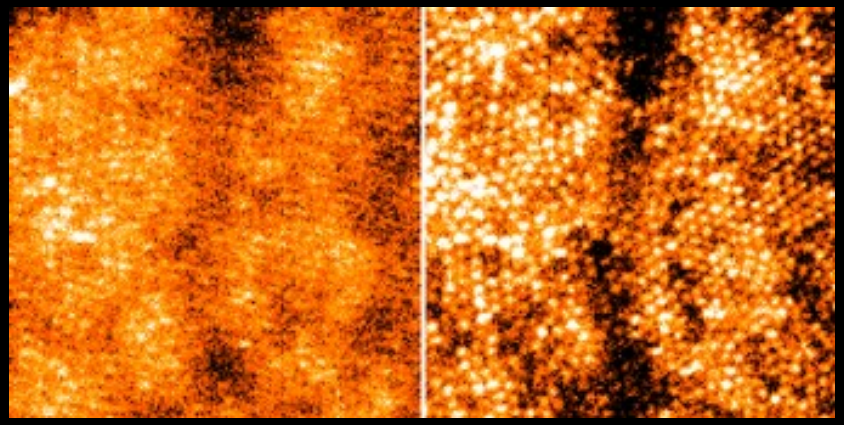
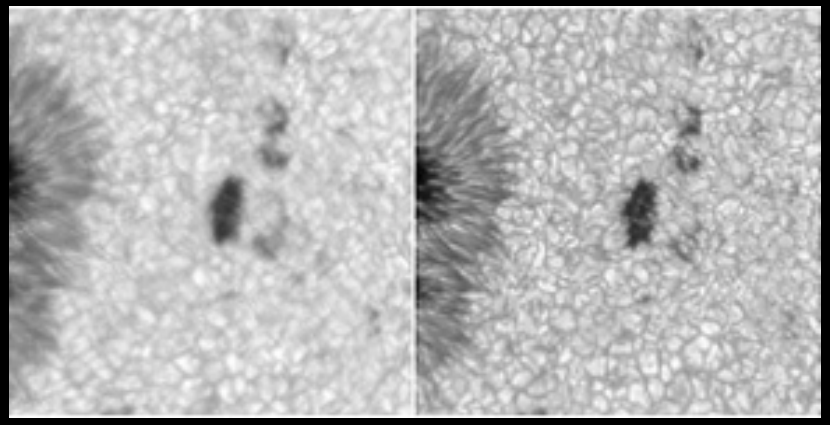
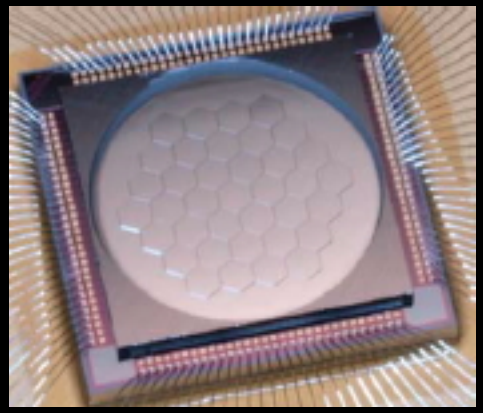


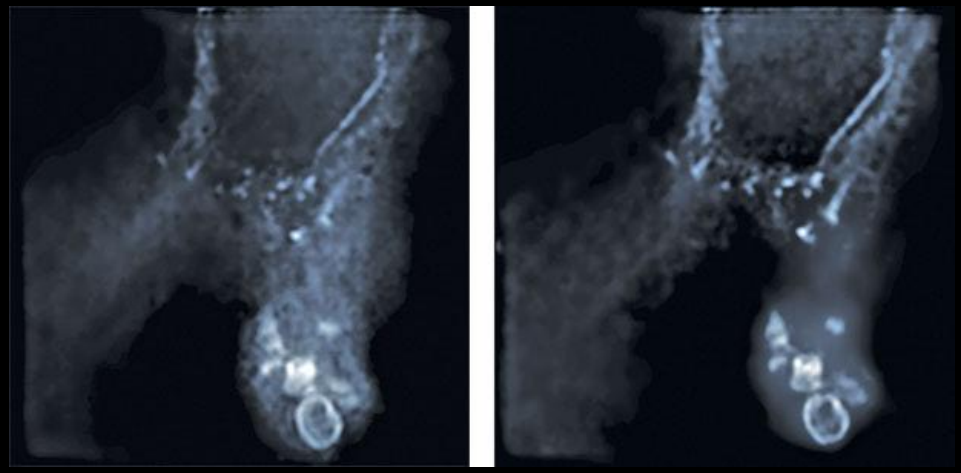


Adaptive Optics

Special Topic in Astrophysics

ASTRON 250 - Fall 2013





Homework

- Let's discuss your results!
- Strehl ratio? r_0? Time/wavelength dependence?
- Binary properties?
- Which methods did you use?

Wavefront correction methods

- Goal: apply a deliberate aberration in an optical system to compensate for unwanted ones
- As for wavefront sensing, there are many methods, and none is perfect…
  - Many factors to be considered in selecting one method over all others

Transmission *vs.* reflexion

- A corrugated wavefront can be corrected via
  - a transmission device whose refractive index can be adjusted: Spatial Light Modulator
  - a reflective device whose surface can be adjusted: Deformable Mirror

Transmission *vs.* reflexion

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+ SLMs can adjust phase and intensity, while DMs can only adjust phase

– SLMs are λ- and polarization-dependent, and cannot "phase wrap"

DM properties to consider (I)

- Number of actuators
- Spatial density of actuators
- Amplitude of displacement (stroke)
  - Absolute for one actuator
  - Local (i.e., for two neighboring actuators)
- Bi-directionality of displacement
- Influence function and actuator coupling
- (Non-)Linearity of response

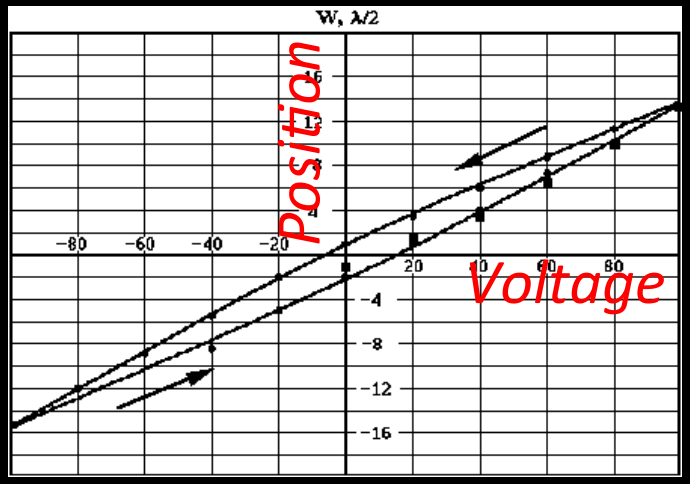
DM properties to consider (II)

- Temporal response of an actuator
  - "rise time", "settling time"
- Quality of actuator response
  - Precision
  - Repeatability
- Hysteresis
- Quality of "flat" mirror and overall calibration
- Fraction of dead/faulty actuators

DM properties to consider (III)

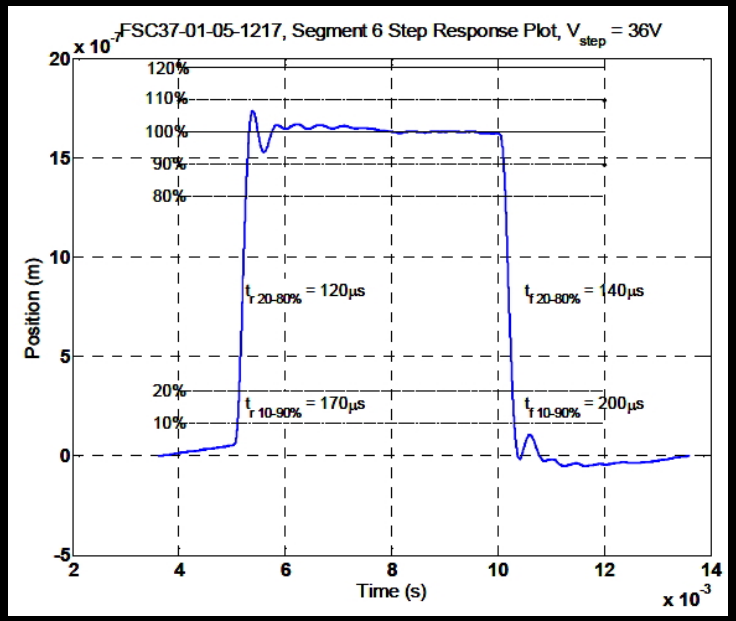
- Operating voltages and currents
- Weight
- Response to environment (T, humidity, vapor)
- Cost
- Durability
- Repair/replacement practicality

Some key parameters



© TURN

Hysteresis



Temporal response

© IrisAO

© AZO Optics

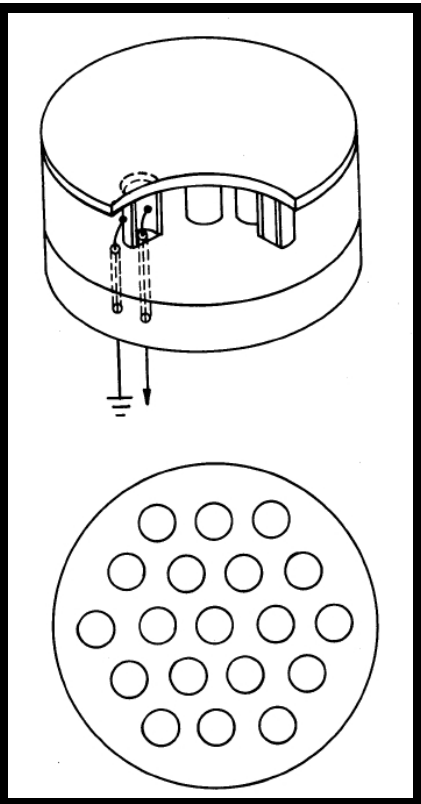
Influence functions

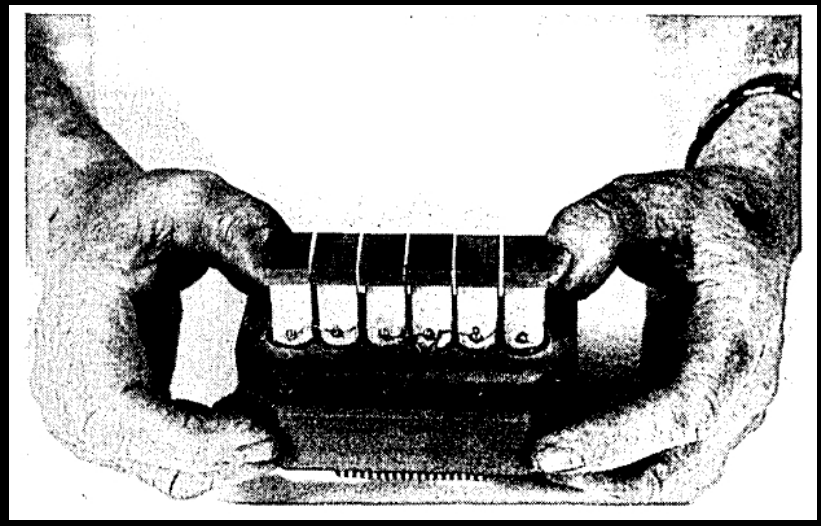
Two generic categories of DMs

Continuous face-sheet/membrane

Segmented

McCall et al. (1977)

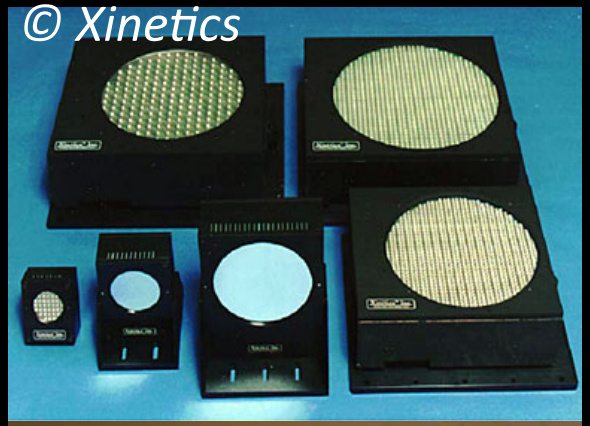




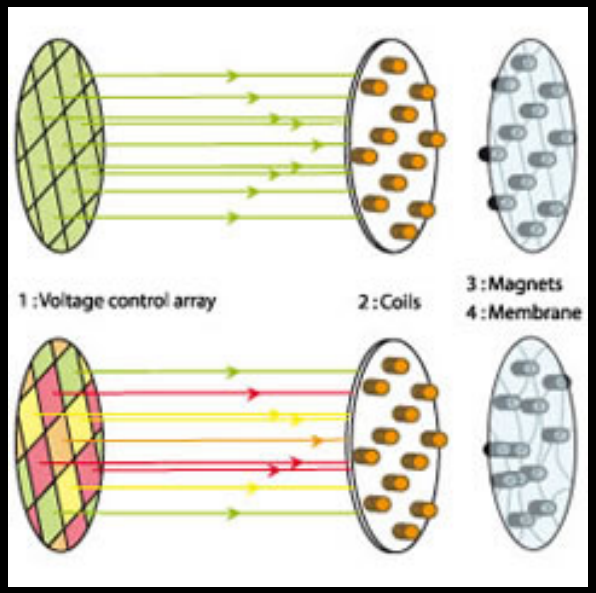
Buffington et al. (1977)

Locally-controlled DMs

Piezo-electric



Magnetic



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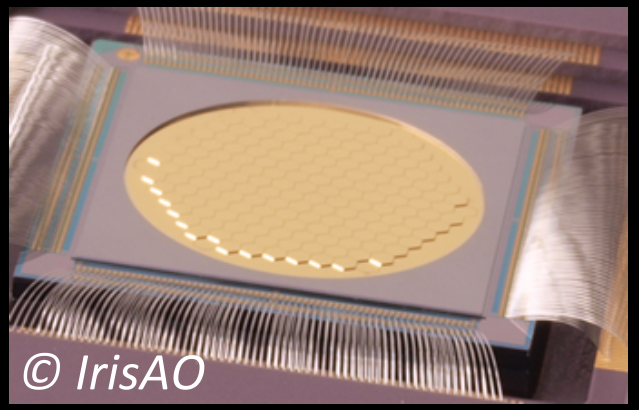
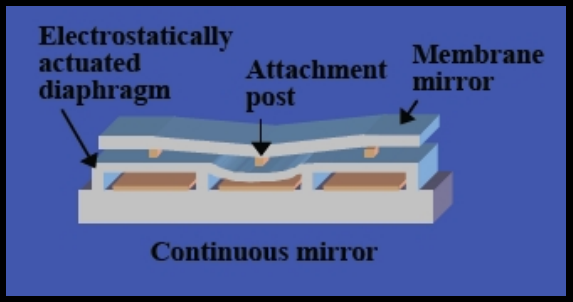
Electrostatic MEMS

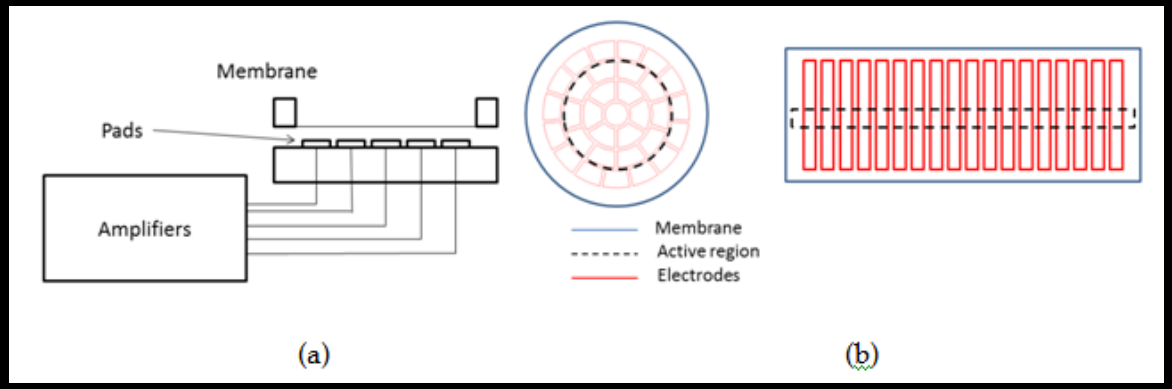




DM shape set in zonal manner

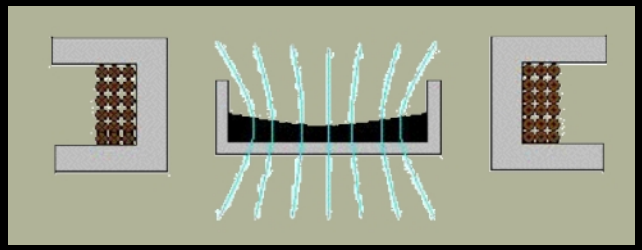
Globally-controlled DMs

Membrane mirror



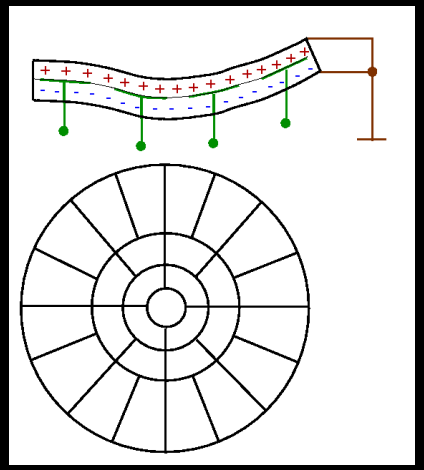
Credit: InTechOpen

DM shape set in “modal” manner

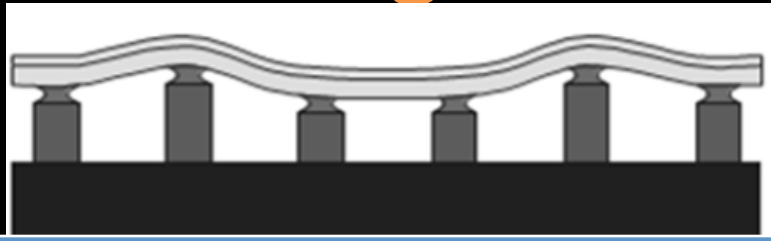


Ferro-fluid mirror

Bimorph mirror



Two generic categories of DMs



Continuous	Segmented
Smooth WF surface No loss of light (gaps) Modal correction	**Easier control** Larger strokes Scalable to many actuators Microchip-sized option
Cross-actuator influence “Dead” actuators problem Smaller strokes Hysteresis Larger physical size	**Discretization of WF** **Edge discontinuities** Loss of light in gaps Diffraction off edges

Using multiple “DMs”

- In most situations, the mode requiring the most stroke is global tip-tilt
  - Use a dedicated flat mirror on a tilting platform

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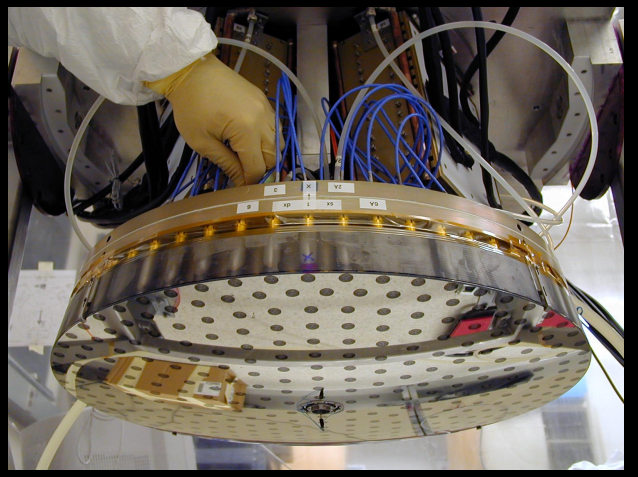
- In most situations, the mode requiring the most stroke is global tip-tilt
  - Use a dedicated flat mirror on a tilting platform
- Focus term can (sometimes) be offloaded to a dedicated motorized focus stage
- Residual high-order aberrations can be dealt with a separate DM of relatively modest stroke, or use 2 successive DMs
- This is a typical woofer-tweeter set-up

Secondary DM

- A particular set-up: using the secondary mirror of a telescope as a DM
  - + Can achieve high density of actuators (size ~ 1m)
  - + Minimize AO-related optics
  - + Larger field-of-view
  - – Not in pupil plane (Fresnel…)
  - – Complex control system



- Currently achieving the highest Strehl ratios on large telescopes (LBT)

Next week

- Michael Helmbrecht (IrisAO) on MEMS DMs
- (re-)Readings on PSF reconstruction and deconvolution:
  - Véran et al. (1997, §1-3)
  - ten Brumelaar et al. (1996)
  - Christou (1999)