The ILMT:

Testing method for the mercury surface quality
Summary

• Basics and defects of LMT's

• Type of wavelets

• Detection and characterization method

• Wavelets modeling

• Impact on the telescope PSF
Basics on Liquid Mirror Telescopes

- Rotating fluid → parabola
- Reflective fluid (Mercury) → Parabolic Mirror

Liquid Mirror Telescope:
- Liquid Mirror
- Camera at focal point
LMT's: Main Characteristics

- Particularities:
  - Zenithal pointing
  - Real-time imaging
  - 20 times cheaper than conventional technology

- Interest:
  - Strip of sky Photometric & Astrometric monitoring
  - Variability study of strip of sky
Defects on LMT's surface

- Time independent defects:
  - Coriolis
  - Non uniformity of gravitational acceleration
  - Axes tilt

- Time dependent defects: wavelets
  - Transient wavelets: gusp of wind, flies, …
  - Stationary wavelets: spiral and concentric
Concentric wavelets

- Vibration induced
- Transmitted by:
  - air bearing,
  - Rotation speed instability
  - Ground vibration, ...

- Characteristics:
  - Wavelength: ~ 1-3 cm
  - Amplitude: ~ 1-3 μm
  - Frequency: ~ 15 Hz
Spiral wavelets

- Wind induced pattern
- Due to:
  - relative velocity air – Mercury
  - instability in the air boundary layer at air-Mercury interface
- Characteristics:
  - Wavelength: ~ 2-5 cm
  - Amplitude: ~ 1-3 μm
  - Frequency: ~ 5 Hz
Detection Method

• Laser reflected on the mercury

• If wavelets :
  ➔ slope modification at impact point
  ➔ deflection of reflected ray

• “Laser line” (instead of a spot)
Impact of Concentric wavelets

- Beam section: horizontal line

- On the detector: Oscillation of the line

- Oscillation on detector:
  - Amplitude ~ mm
  - Related to Local slope modification induced by wavelet
  - Related to $A, k$
  - Frequency = wavelet frequency

$A = 1.5 \, \mu m, \lambda = 3 \, cm, d = 1.5 \, m$
Impact of spiral wavelets

- Beam section: horizontal line
- On the detector: Sinusoid propagating through the line
- Sinusoid on detector:
  - Amplitude $\sim$ mm
  - Amplitude and wavelength related to $A$, $k$
  - Frequency $=$ wavelet frequency

$A = 1.5 \mu m$, $\lambda = 3 \text{cm}$, $d = 1.5 \text{m}$
What can we measured?

- Locally: wavelets = plane wave
- Beam section : horizontal line
- If Laser line // wave front:
  - Detector = oscillating line
  - Oscillation Amplitude $\rightarrow$ retrieve “Ak” product
What can we measure?

- If $\beta$ angle between line and wavefront:
  - Detector: sinusoid
  - Amplitude: $\alpha A k \sin(\beta)$
  - Wavelength:
    $$\alpha (k \sin(\beta))^{-1}$$
- Rotation of incident beam $\rightarrow$ retrieve all parameters!
Raise the degeneracies: inclined measures

- Measure 1:
  - Spiral: $A, k \sin(\beta)$
  - Concentric: $A*k$

- Measure 2,3:
  - Spiral: $k \sin(\beta \pm \alpha)$
  - Concentric: $A*k\sin(\pm \alpha)$

- Spiral: $A, k, \beta$ known
- Concentric: $A, k$ known
Modeling Concentric wavelets

- Local detection method → no constraint on wavelets modeling!

- Wavelets model:
  \[ z = A(r) \cos(kr - \omega t) \]

- Parameters:
  \[ A(r), k, \omega \]
Modeling Spiral wavelets

- Model:
  \[ z = A(r) \cos(\phi + (1 - r/R)) \cos(\omega t) \]

- Measurable quantities:
  \[ A(r), \beta(r), k(r), \omega \]

- Known introduced phase aberration!
Impact of spiral wavelets on PSF

- Known introduced phase aberration

- *Nijboer Zernike* approach: impact on PSF

- Impact of the wavelets:
  - Increasing number of wavelets $\rightarrow$ bigger diffraction ring
  - Increasing amplitude $\rightarrow$ decreasing Strehl ratio
Conclusion

• New method for testing liquid mirrors: reflected laser

• Possible to fully characterize spiral and concentric wavelets

• Wavelets modeling → Impact on PSF and quality of the telescope