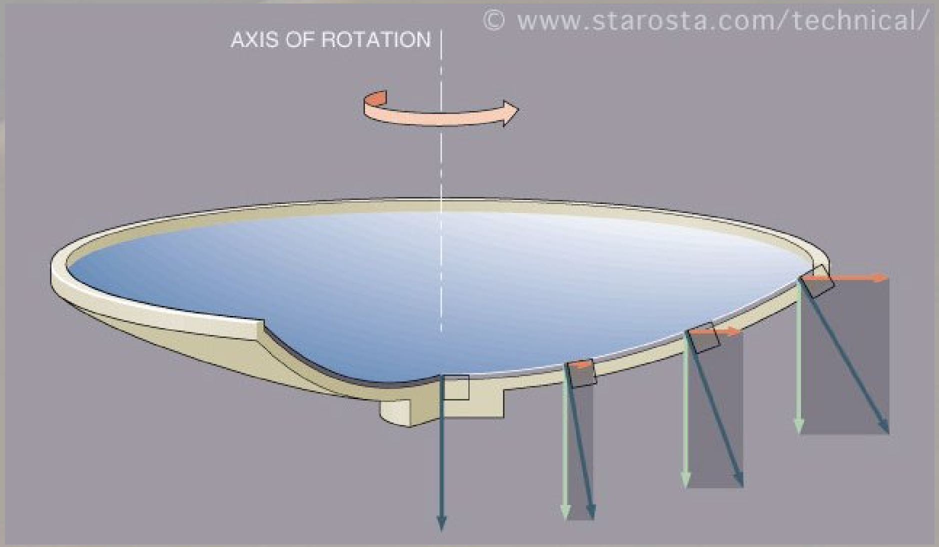
The ILMT:

Testing method for the mercury surface quality

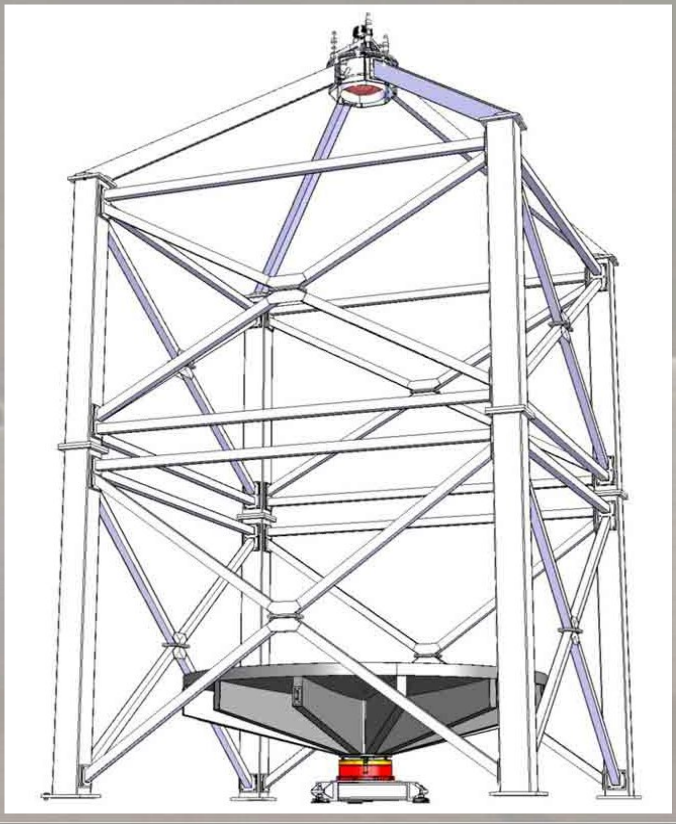
Summary

- 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

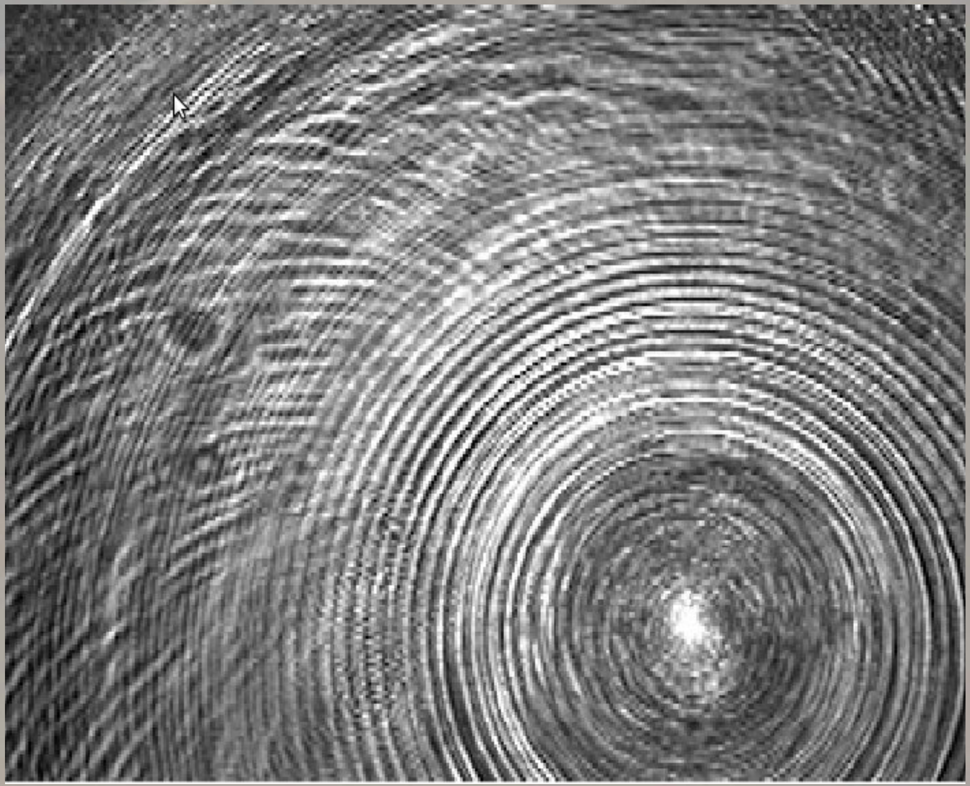
- Time independent defects:
  - Coriolis
  - Non uniformity of gravitational acceleration
  - Axes tilt

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

Concentric wavelets

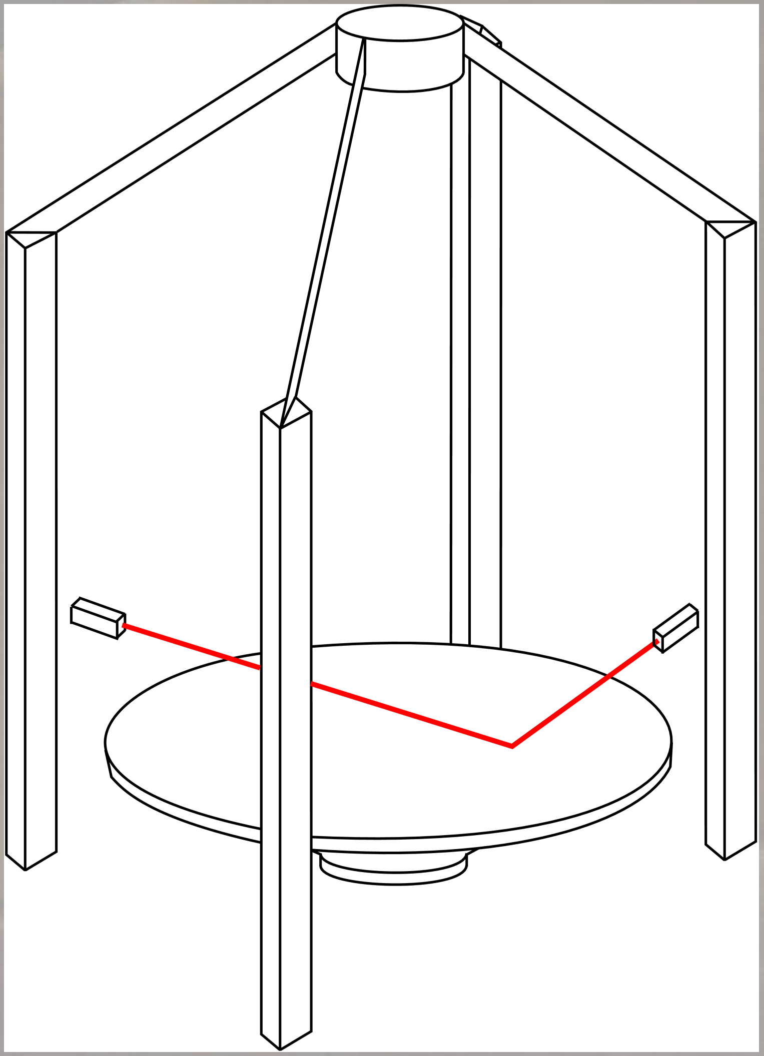
- Vibration induced
- Transmitted by :
  - air bearing,
  - Rotation speed instability
  - Ground vibration, ...
- Characteristics:
  - Wavelength : ~ 1-3 cm
  - Amplitude : ~ 1-3 μm
  - Frequency : ~ 15 Hz

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 : ~ 1-3μm
  - 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

$$A = 1.5(\mu m), \lambda = 3(cm), d = 1.5(m)$$

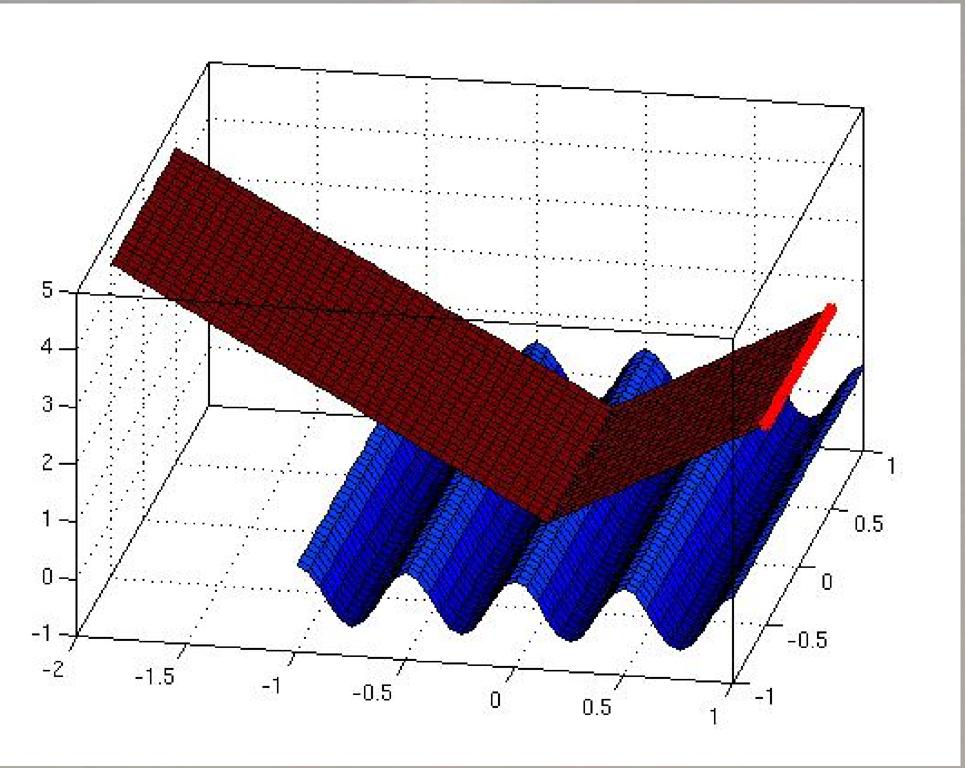
- Beam section : horizontal line
- On the detector : Oscillation of the line
- Oscillation on detector:
  - Amplitude ~ mm
  - Related to Local slope modification induced by wavelet
  - Related to A, k
  - Frequency = wavelet frequency

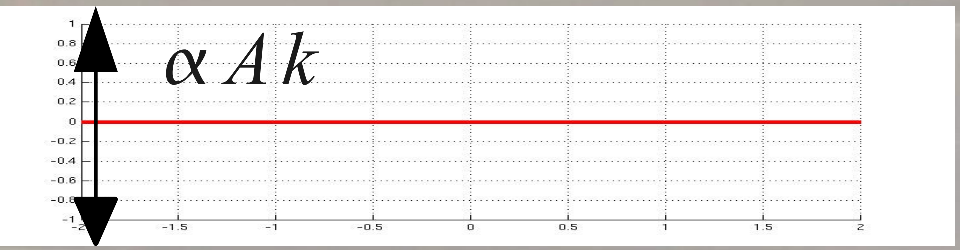
Impact of spiral wavelets

$$A = ۱.۵\,(\mu m),\ \lambda = ۳\,(cm),\ d = ۱.۵\,(m)$$

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

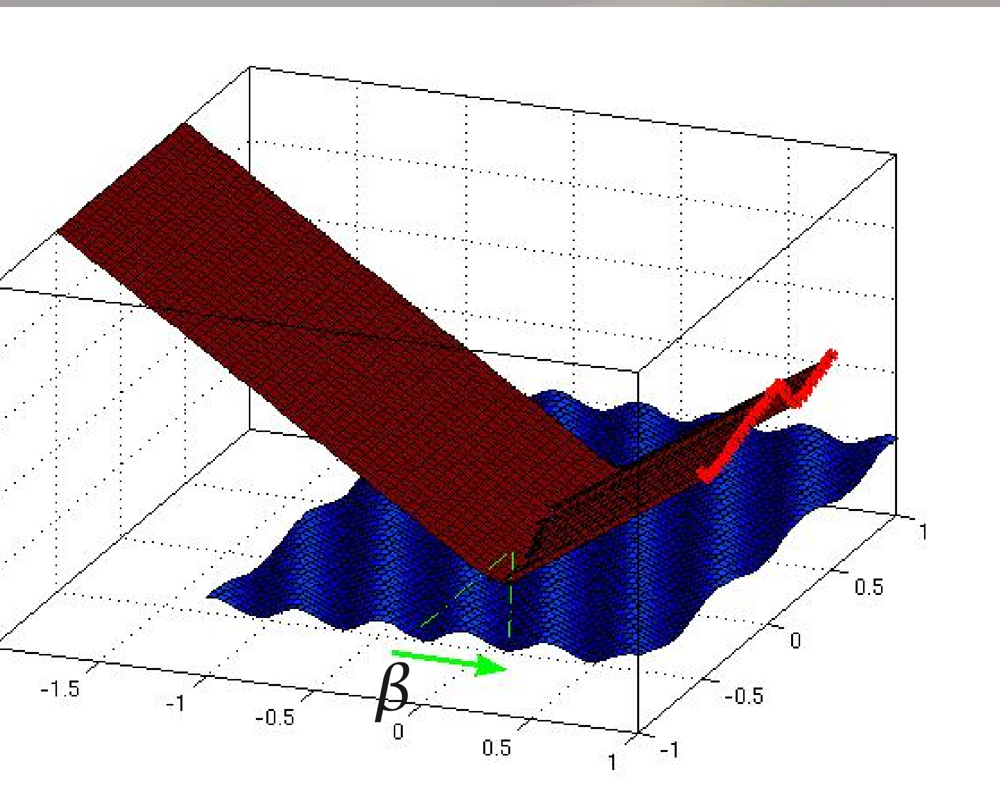
What can we measured?



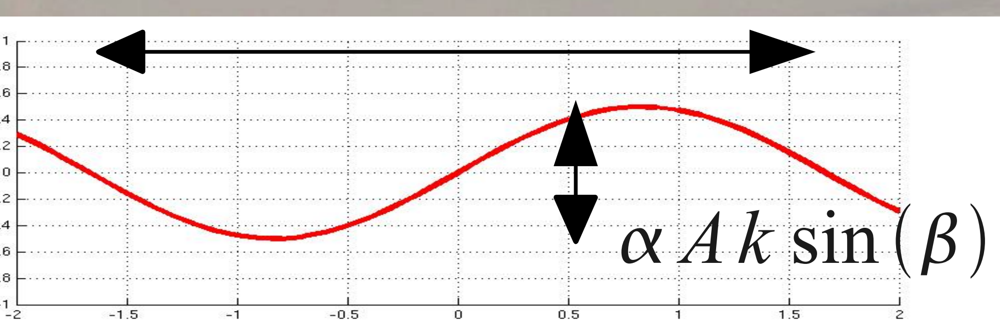


- Locally: wavelets = plane wave
- Beam section : horizontal line
- If Laser line // wave front:
  - Detector = oscillating line
  - Oscillation Amplitude → retrieve "Ak" product

What can we measure?



$$\alpha (k \sin(\beta))^{-1}$$

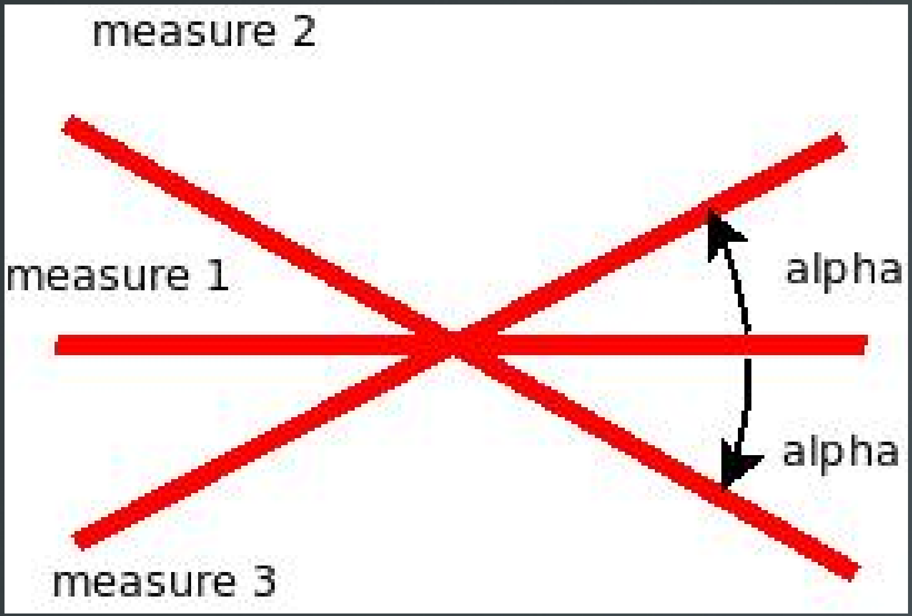


- If β angle between line and wavefront:
  - Detector : sinusoid
  - Amplitude: $\alpha A k \sin(\beta)$
  - Wavelength :

$$\alpha (k \sin(\beta))^{-1}$$

- Rotation of incident beam → retrieve all parameters!

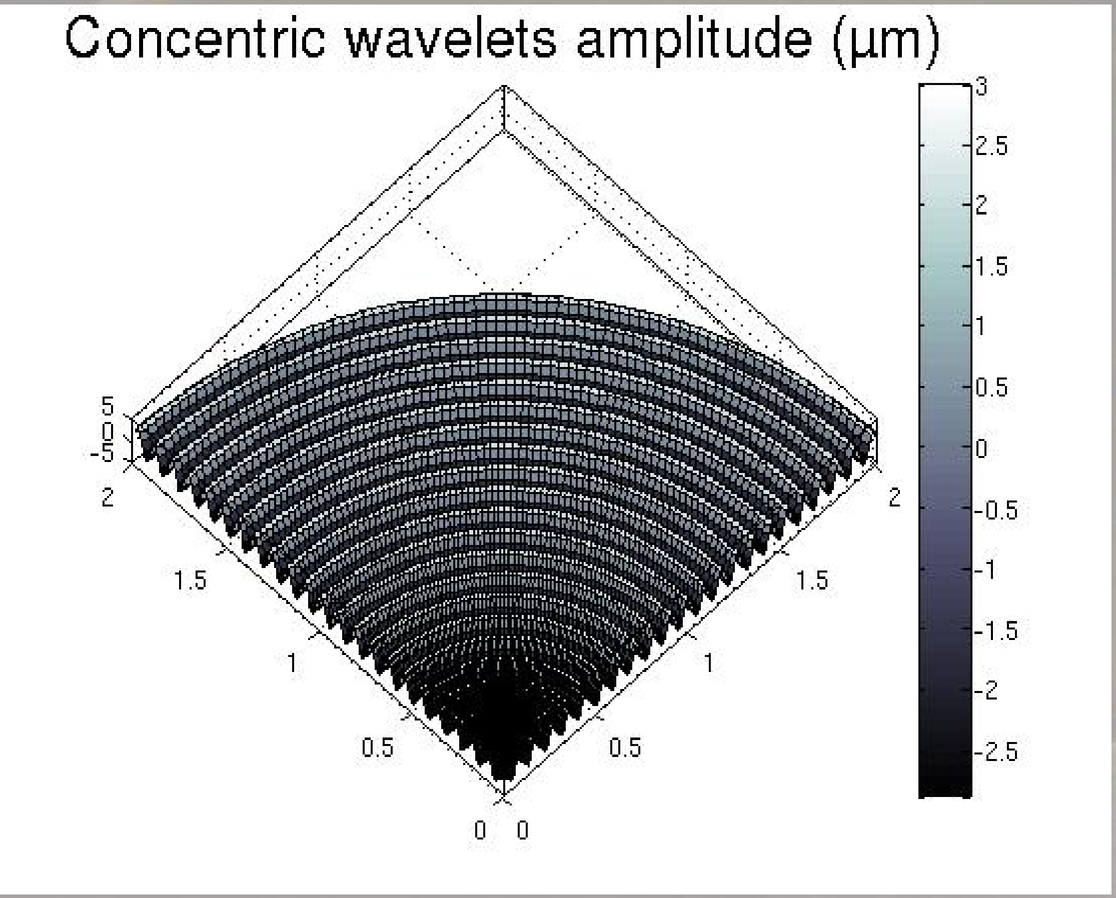
Raise the degeneracies: inclined measures



- Measure 1 :
  - Spiral: A, k*sin(β)
  - Concentric: A*k
- Measure 2,3:
  - Spiral : k*sin($\beta \pm \alpha$)
  - Concentric: A*k*sin($\pm\alpha$)

- Spiral : A, k ,β known
- Concentric : A, k known

Modeling Concentric wavelets



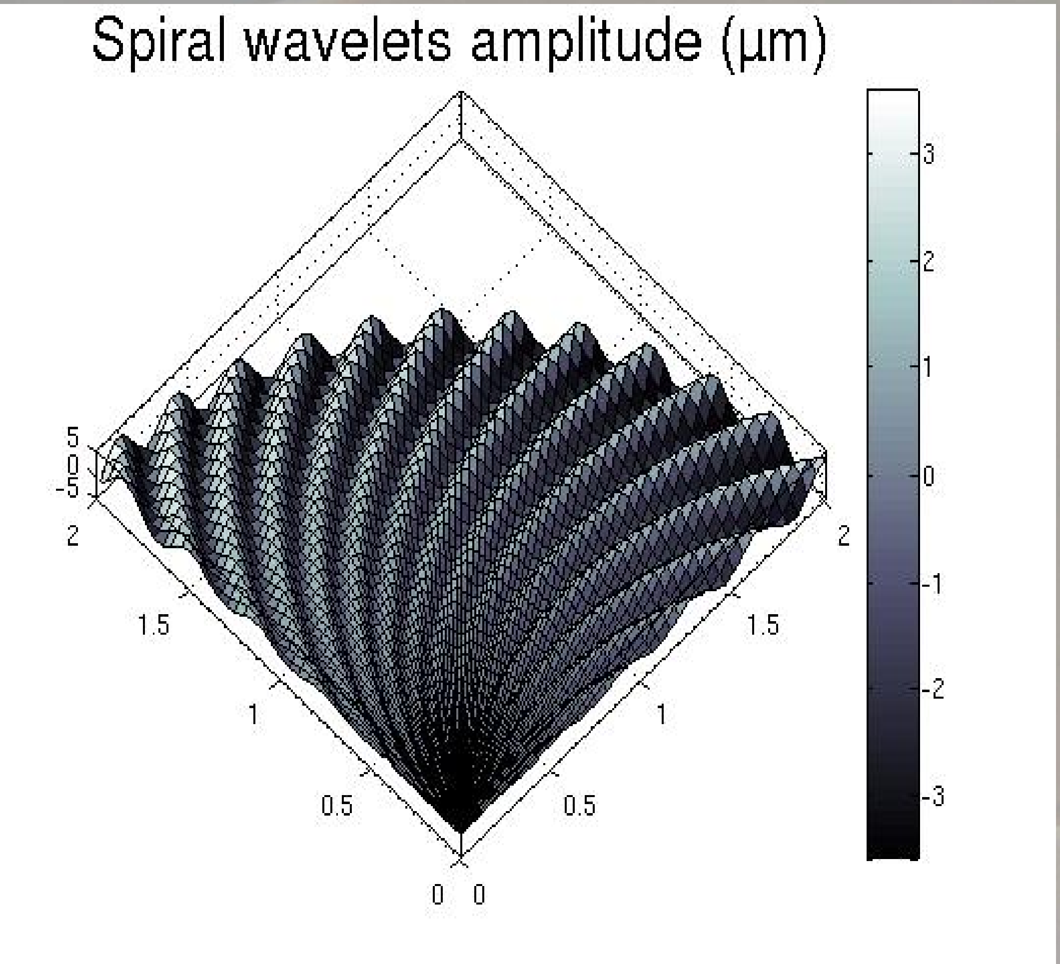
- Local detection method → no constraint on wavelets modeling!
- Wavelets model:

$$z = A(r)\cos(kr - \omega t)$$

- Parameters:

$$A(r), k, \omega$$

Modeling Spiral wavelets



- Model :

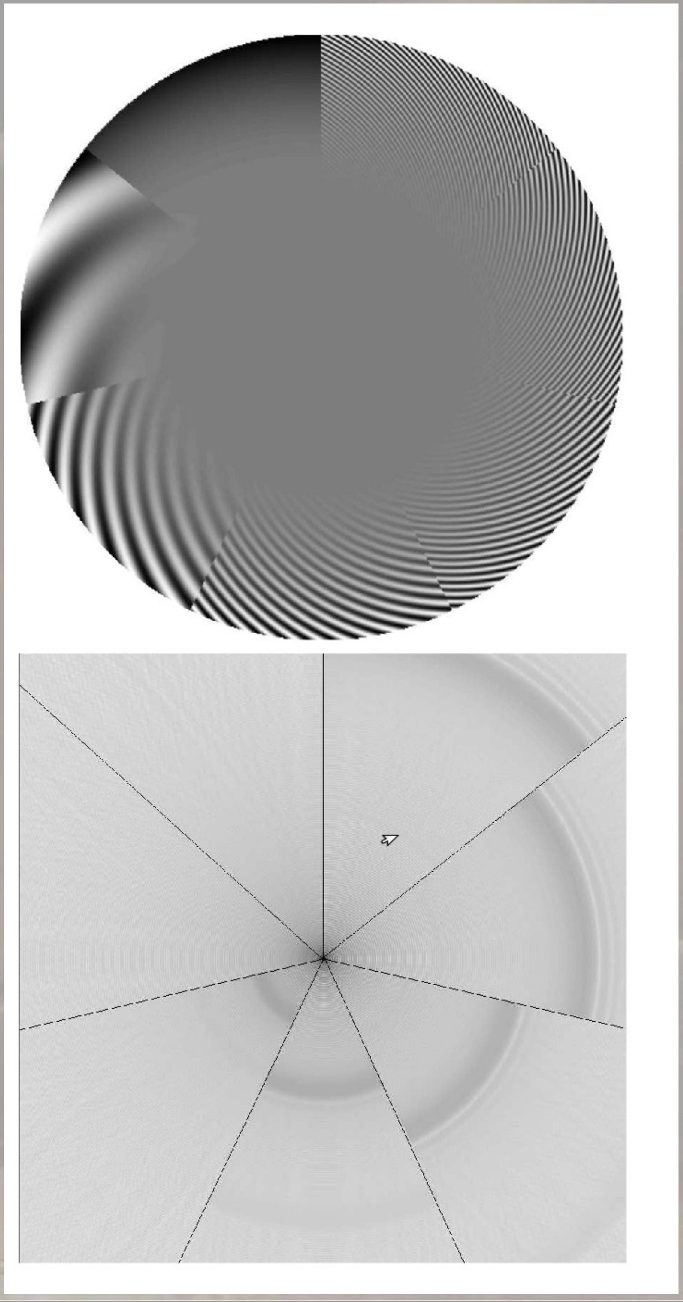
$$z = A(r)\cos(N(\phi + (1 - r/R)))\cos(\omega t)$$

- 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 → bigger diffraction ring
  - Increasing amplitude → 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