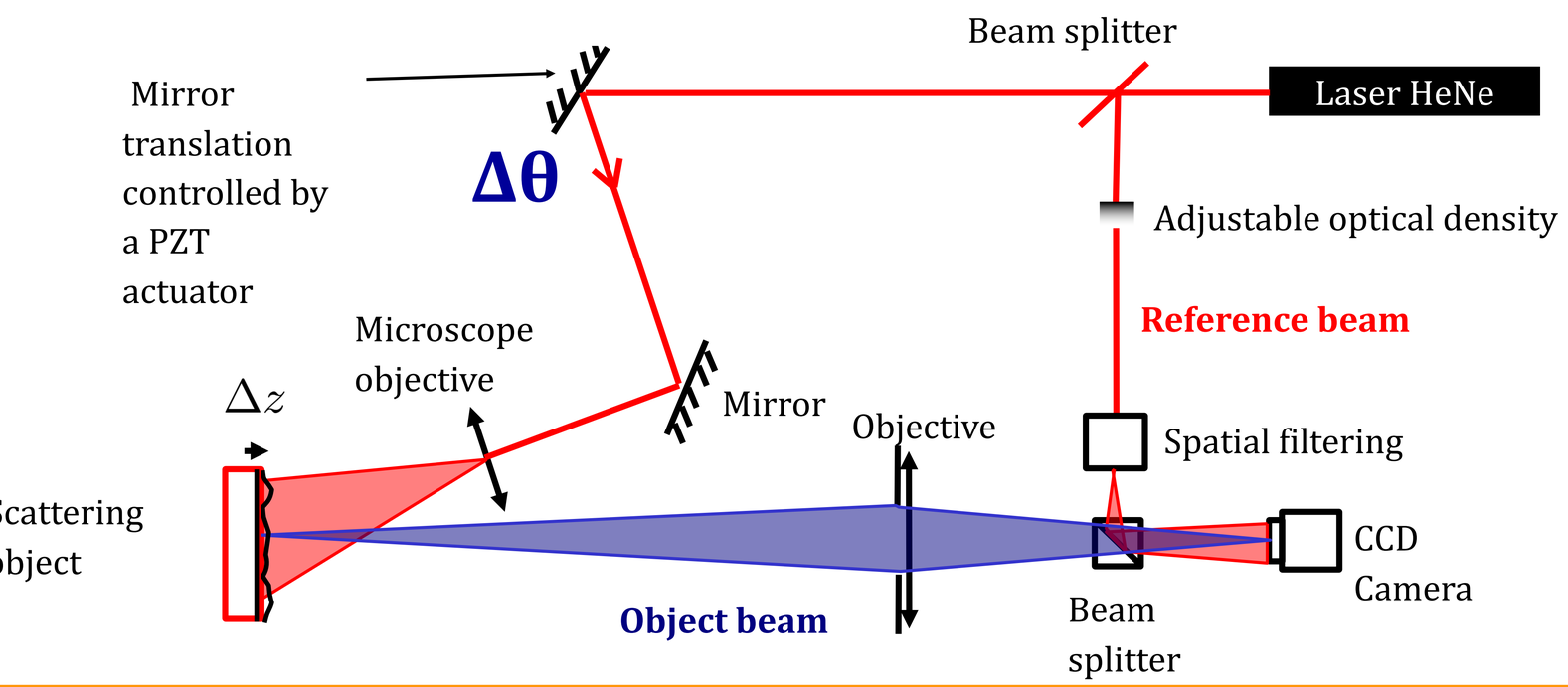
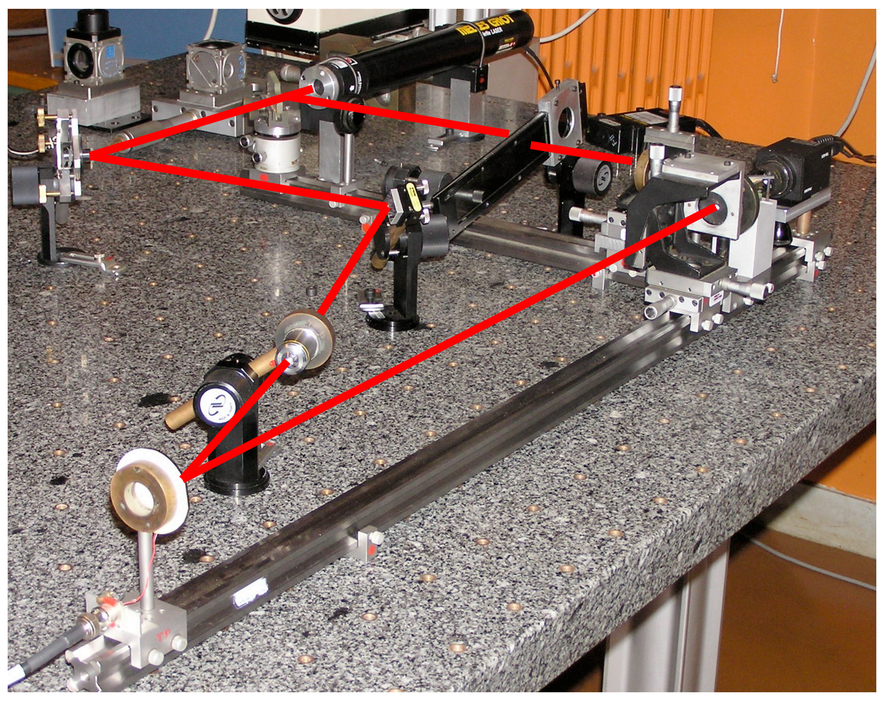
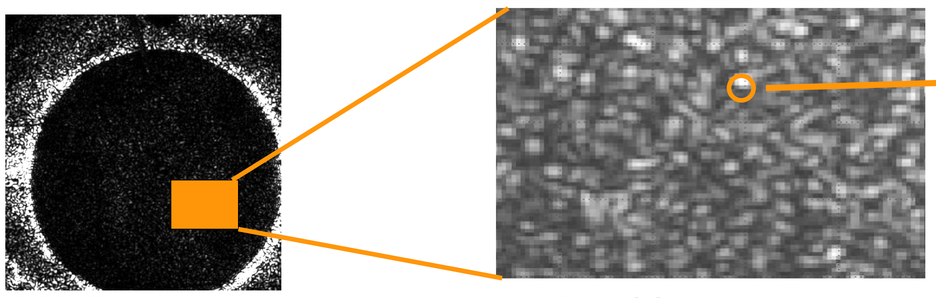
INSTITUT d'OPTIQUE GRADUATE SCHOOL

Digital holography



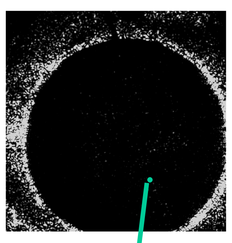
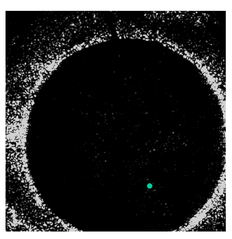
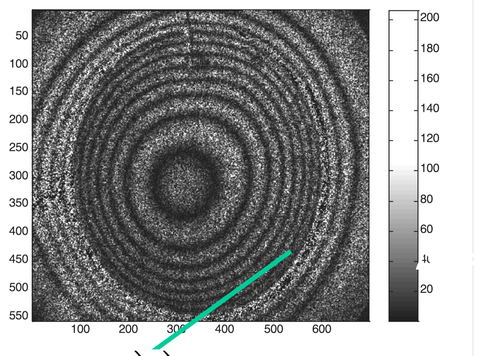




$$I_1(x,y) = I_0\left(1 + m\cos\left(\Delta\phi(x,y)\right)\right)$$

$$\Delta\phi(x,y) = \underbrace{\Delta\varphi(x,y)}_{\text{Phase difference between the two channels}} + \underbrace{\varphi_s(x,y)}_{\text{Random phase (constant on a speckle grain)}}$$

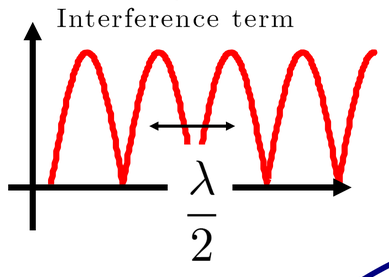
Image #2 − **Image #1** =

After deformation **Before deformation**

$$I_2(x,y) = I_0\left(1 + m\cos\left(\Delta\phi(x,y) - \frac{4\pi}{\lambda}\Delta z(x,y)\right)\right)$$

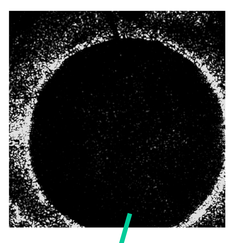
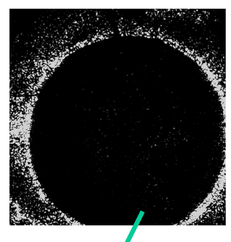
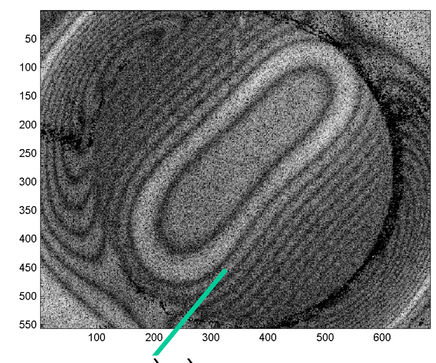
$$|I_2(x,y) - I_1(x,y)| = \left|\underbrace{I_0 m \sin\left(\frac{2\pi}{\lambda}\Delta z(x,y)\right)}_{\text{Interference term}}\underbrace{\sin\left(\Delta\phi(x,y) - \frac{2\pi}{\lambda}\Delta z(x,y)\right)}_{\text{speckle modulation}}\right|$$



Numerical difference between 2 images

Phase-shift methods

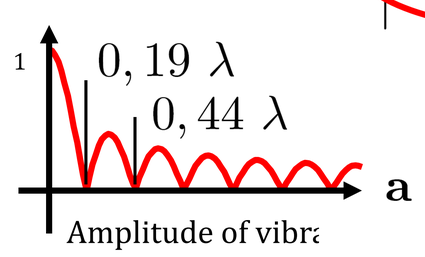
Image #2 − **Image #1** =

Vibration on Δθ= π **Vibration on Δθ=0**

$$= \int I_0\left(1 + m\cos\left(\Delta\phi(x,y) - \underbrace{a\cos(\omega t)}_{\text{vibration}} - \Delta\theta\right)\right)dt$$

$$|I_2(x,y) - I_1(x,y)| = \left|mI_0\cos\left(\varphi_s(x,y)\right)\right|\left|J_0\left(\frac{4\pi}{\lambda}\mathbf{a}(x,y)\right)\right|$$

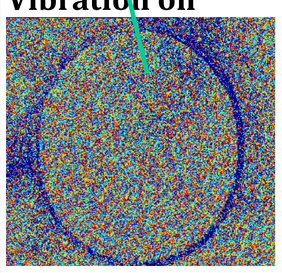
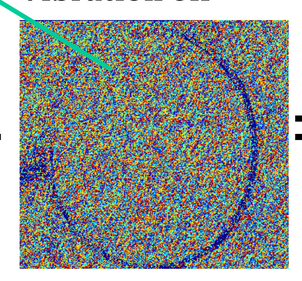
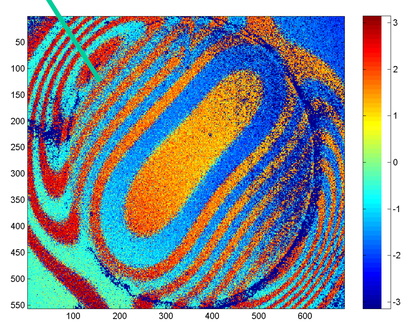


$$= \begin{cases} 0 \text{ if } J_0\left(\frac{4\pi}{\lambda}\mathbf{a}\right) > 0 \\ \pi \text{ if } J_0\left(\frac{4\pi}{\lambda}\mathbf{a}\right) < 0 \end{cases}$$

$$\arctan\left(\frac{\sin(\Delta\phi)\,J_0\left(\frac{4\pi}{\lambda}\mathbf{a}\right)}{\cos(\Delta\phi)\,J_0\left(\frac{4\pi}{\lambda}\mathbf{a}\right)}\right)$$

$\Delta\phi(x,y)$

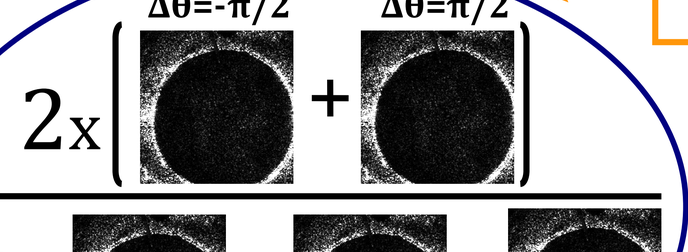
Vibration on **Vibration off**

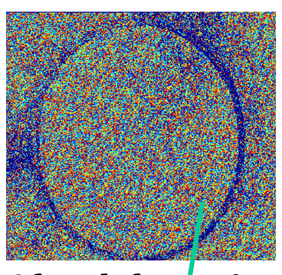
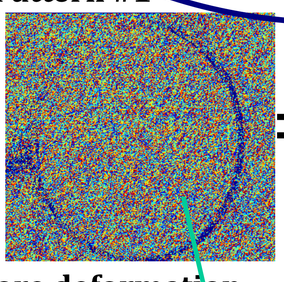
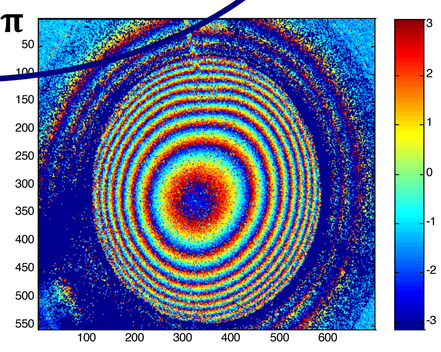
Quasi-binary fringes

Vibration analysis

$$\arctan\left(\frac{2\times\left(\text{Δθ=-π/2} + \text{Δθ=π/2}\right)}{2\times\text{Δθ=π/2} - \text{Δθ=-π/2} - \text{Δθ=π}}\right)$$

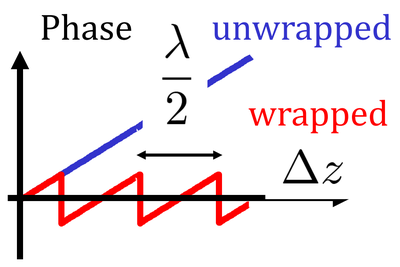


Phase Pattern #2 **Phase Pattern #1**

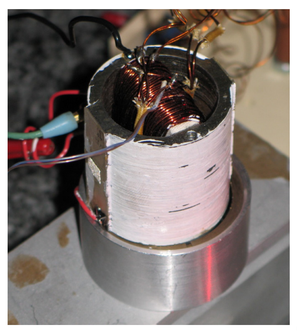
After deformation **Before deformation**

$$\Delta\phi(x,y) - \frac{4\pi}{\lambda}\Delta z(x,y) \qquad \Delta\phi(x,y)$$

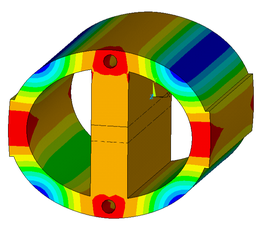


Static deformation

Vibration analysis in collaboration with **Satie** research laboratory

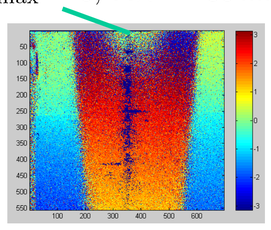


Electro-mecanical structure



Simulation model of mode #1 of vibration

$\mathbf{a}_{\max} = 0,44\lambda \approx 280\,\text{nm}$



$\mathbf{a}_{\max} = 0,9\lambda \approx 560\,\text{nm}$

Measures with the two methods above

Lionel Jacubowiez, Thierry Avignon, Xavier Mininger*, Fabienne Bernard 2005