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Stray light in the LISA instrument

characterization and modelling of the coherent perturbation of a homodyne interference

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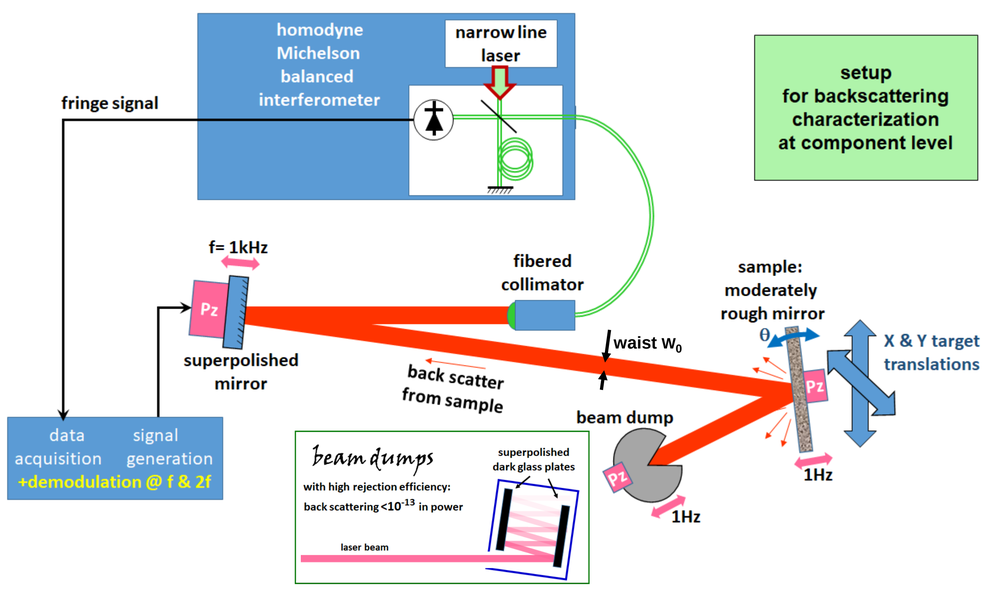
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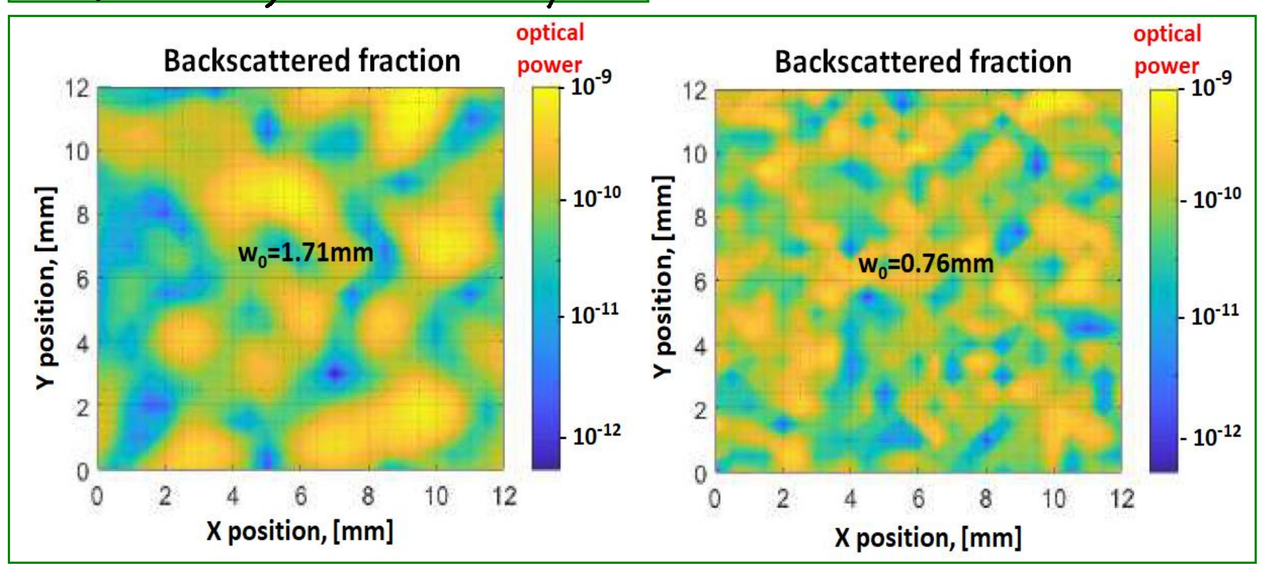
Goals of this study

- achieve coherent detection of light back-scattered by a mirror
- characterize **dependence with spot position, and incidence angle**
- test cross-polarization scattering
- develop an **accurate modelling** of this coherent perturbation (electromagnetic optics formalism)
- provide scattering requirements **at component level**

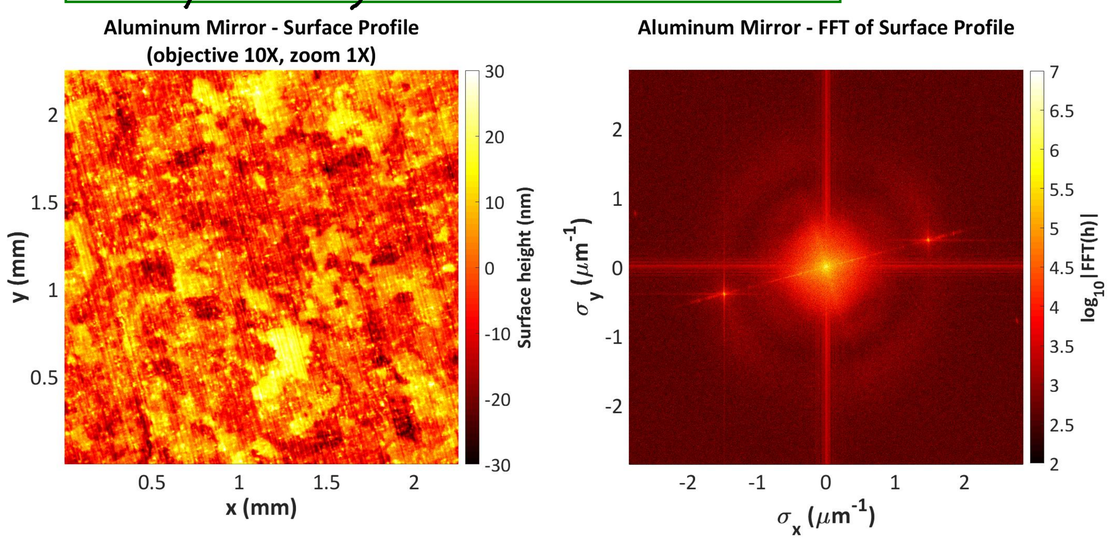
Experimental activities



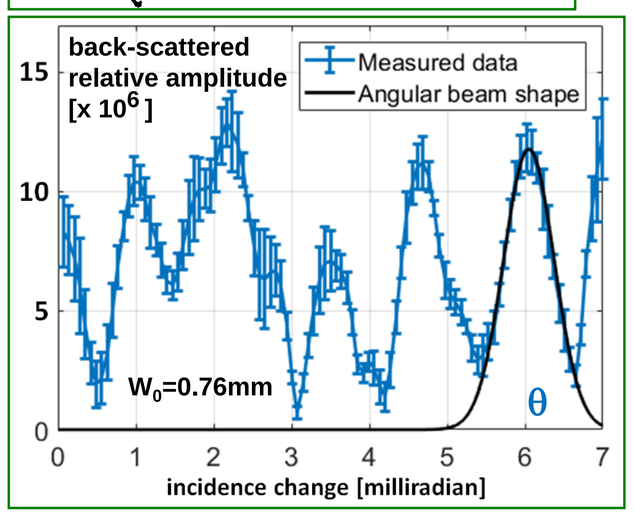
X-Y scan of the beam spot



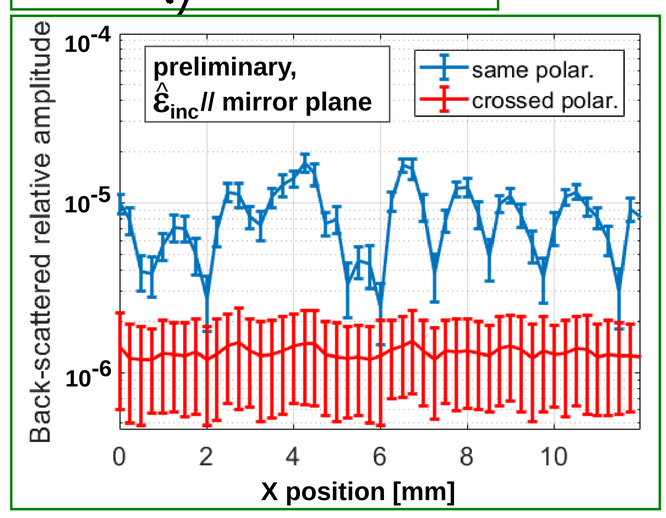
Sample roughness measurement



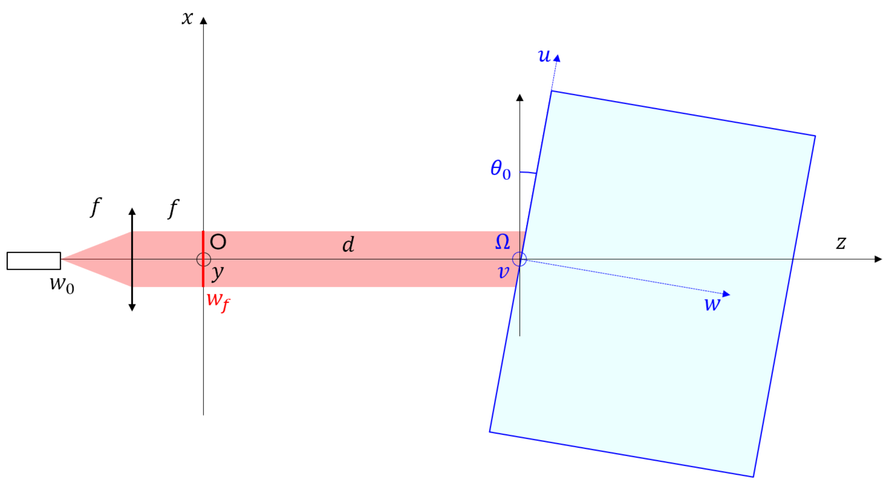
incidence scan near 14°



crossed polarization



Theoretical modelling



- Spatial distribution of the incident field (Gaussian mode)

$$\vec{\mathcal{E}}(x,y,z) = \frac{w_f^2}{4\pi}\vec{\mathcal{E}}_0 \iint e^{-\frac{w_f^2}{4}(\sigma_x^2+\sigma_y^2)} e^{i[x\sigma_x+y\sigma_y+z\alpha_{0,xy}]}\, d\sigma_x d\sigma_y$$

- Spatial distribution of the back-scattered field in the $z = 0$ plane

$$\vec{\mathcal{E}}^-_{0,s}(x,y,0) = \frac{1}{(2\pi)^4}\int_{\vec{\sigma}_i}\int_{\vec{\sigma}_s} \vec{\mathbb{A}}^-_{0,s}(\vec{\sigma}_s)\, e^{i[(x\cos\theta_0 - d\sin\theta_0)\sigma_{us}+y\sigma_{vs}+\alpha_{0,uvs}(x\sin\theta_0+d\cos\theta_0)]}\, d^2\vec{\sigma}_s\, d^2\vec{\sigma}_i$$

$$\vec{\mathbb{A}}^-_{0,s}(\vec{\sigma}_s) = -\frac{2i}{(\tilde{n}^s_0+\tilde{n}^s_1)(\tilde{n}^i_0+\tilde{n}^i_1)}\,\widehat{h}(\vec{\sigma}_s-\vec{\sigma}_i)\left\{[\tilde{n}^i_0(\alpha^i_1\tilde{n}^i_1-\alpha^i_0\tilde{n}^i_0)-\tilde{n}^s_1(\alpha^i_1\tilde{n}^i_0-\alpha^i_0\tilde{n}^i_1)]\vec{\mathbb{A}}^+_{0,i}(\vec{\sigma}_i)+(\vec{\sigma}_s-\vec{\sigma}_i)\frac{\tilde{\epsilon}_0-\tilde{\epsilon}_1}{\tilde{\epsilon}_0}\frac{\tilde{n}^i_0\tilde{n}^s_1}{\alpha^i_1}\vec{\sigma}_i\cdot\vec{\mathbb{A}}^+_{0,i}(\vec{\sigma}_i)\right\}$$

FT of the surface height profile $h(x,y)$

- Coupling efficiency (overlapping integral)

$$\eta(d,\theta_0) = \frac{\left|\iint \vec{\mathcal{E}}^*(x,y,0)\cdot\vec{\mathcal{E}}^-_{0,s}(x,y,0)\,dxdy\right|^2}{\left|\iint\left|\vec{\mathcal{E}}(x,y,0)\right|^2 dxdy\right|^2}$$

Conclusions

Study of coherent back-scattering from components
- **starting with metal mirror, roughness ≈100Å RMS**

Backscattering speckle-type dependence with
- **spot position (~ 1/ beam waist)**
- **incidence angle (~ 1/ beam divergence)**

Strong attenuation in crossed polarization scattering if $\hat{\varepsilon}_{inc}$// surface
Other configurations not yet studied and may differ

Electromagnetic modelling of the back-scattered field
=> numerical calculation under way

Soon: monitoring of coherent backscattering by dust contamination

References

Michel Lequime, Claude Amra. De l'Optique électromagnétique à l'Interférométrie – Concepts et Illustrations. EDP Sciences, 2013
Claude Amra. Light-Scattering From Multilayer Optics .1. Tools Of Investigation. *Journal of the Optical Society of America. A* **11** (1994), pp.197-210.
Claude Amra. 1st-Order Vector Theory Of Bulk Scattering In Optical Multilayers. *Journal of the Optical Society of America. A* **10** (1993), pp.365-374.
M. Zerrad, M. Lequime, S. Liukaityte, C. Amra. Parasitic light scattered by complex optical coatings: modelization and metrology. *CEAS Space Journal*, 2017,
M. Lintz, A.V. Papoyan , "simple and efficient lasers beam dumps", *Review of Scientific Intruments 71 (2000) p. 4681*

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