Two methods of analysis of wavefronts. Some examples of applications.

Antonio Marzoa[1], Santiago Vallmitjana[1], Salvador Bosch[1] and Eva Acosta[2]

[1]*Departament de Física Aplicada i Òptica, Facultat de Física, Universidad de Barcelona, 08028 Barcelona, Spain*

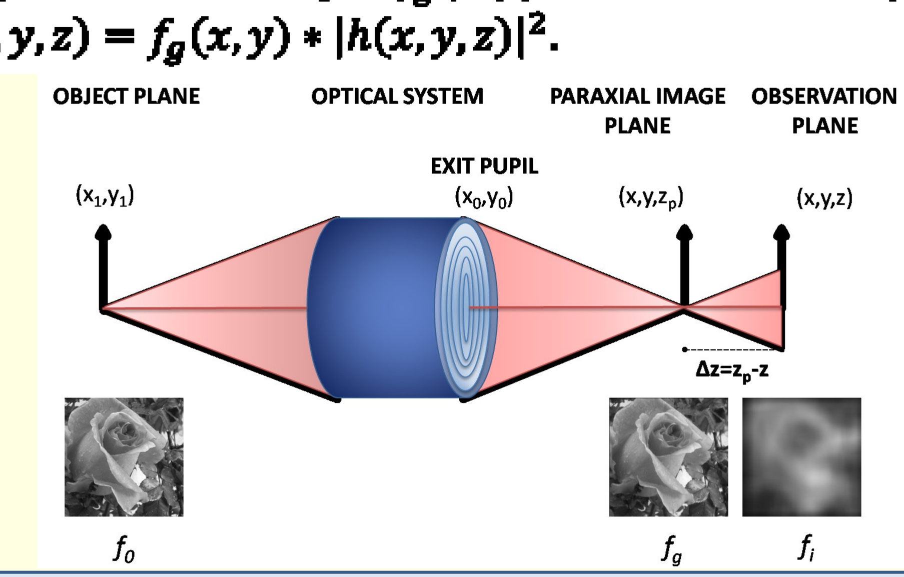
[2]*Departamento de Física Aplicada, Facultade de Óptica e Optometría (Campus Vida), Universidade de Santiago de Compostela, Santiago de Compostela, Spain*

Summary

Two experimental techniques for analyze wavefronts are presented. On one hand a non-contact technique for analyzing the image quality of antique optical instruments is proposed. We use a wavefront sensor, in particular a Shack–Hartmann device placed at the exit of the instrument in combination with a suitable illumination is presented. So, using the experimental parameters provided by the Shack-Hartmann wavefront analyzer (Zernike polynomial coefficients) and our own software we are able to calculate the PSF of the instrument that we are studying, and then calculate the convolution within the PSF and the function that describes a paraxial image. On the other hand we present a technique based on the use of a Point Diffaraction Interferometre (PDI). As examples of applications we have applied this interferometric technique for the measurement of local curvatures and caustics of noisy wavefronts in the particular case of crystalline lenses of fish eyes. This analysis allows us to obtain much information about the imaging of highly aberrated or noisy optical elements such as crystalline lenses of fishes.

Theoretical background: Optical Systems and the PSF

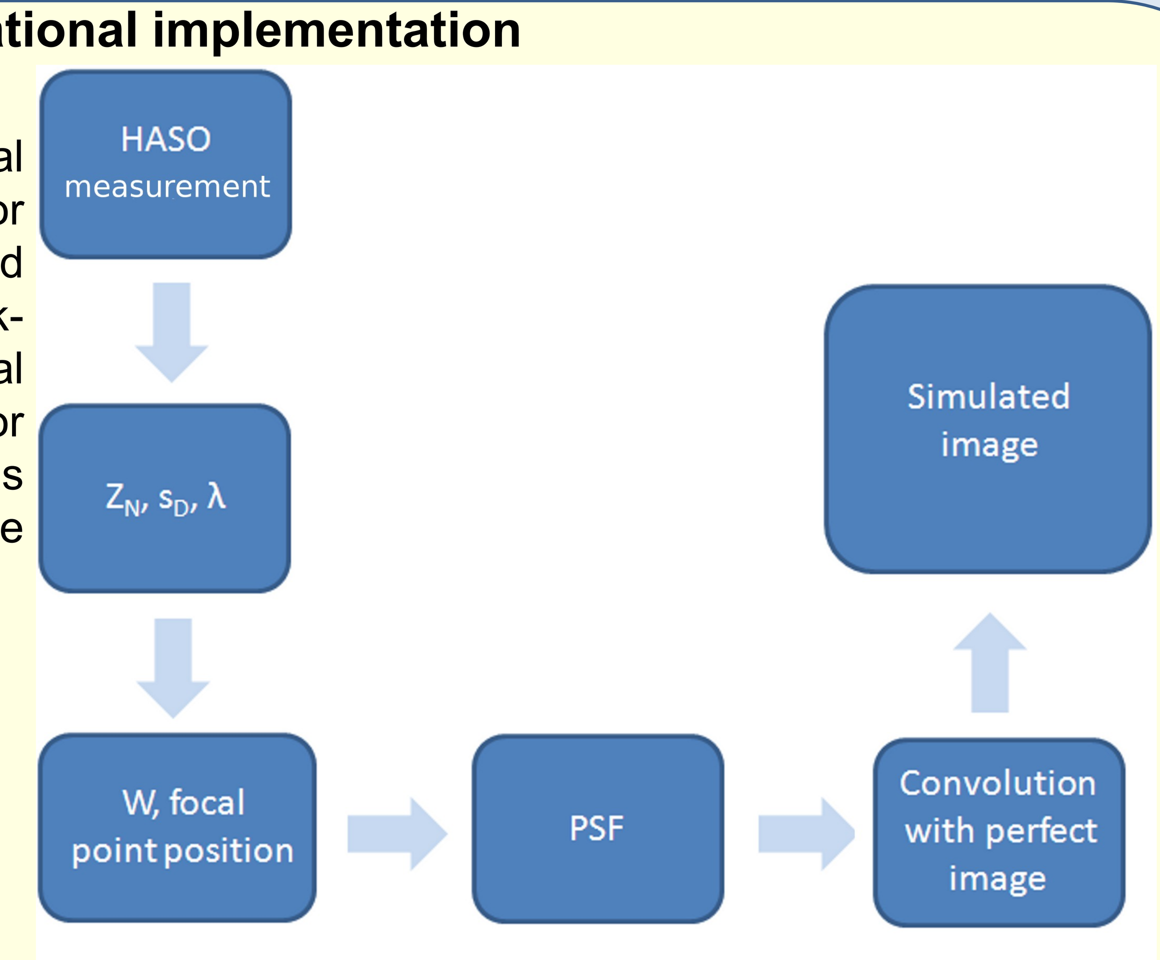
From the geometrical point of view, an optical instrument can be sketched by tracing rays through the surfaces that compose the system, using Snell's law. Moreover, a general imaging device can also be described as a black box consisting of two planes containing the entrance and exit pupils. For a linear and intensity invariant optical system, the intensity pattern in an observation plane at a distance z from the exit pupil can be described as a convolution of the geometrical image, $f_g(x,y)$, and the corresponding incoherent PSF, $|h(x,y,z)|^2$, i.e., $f_i(x,y,z) = f_g(x,y) * |h(x,y,z)|^2$.



eneralized (black box) optical system.

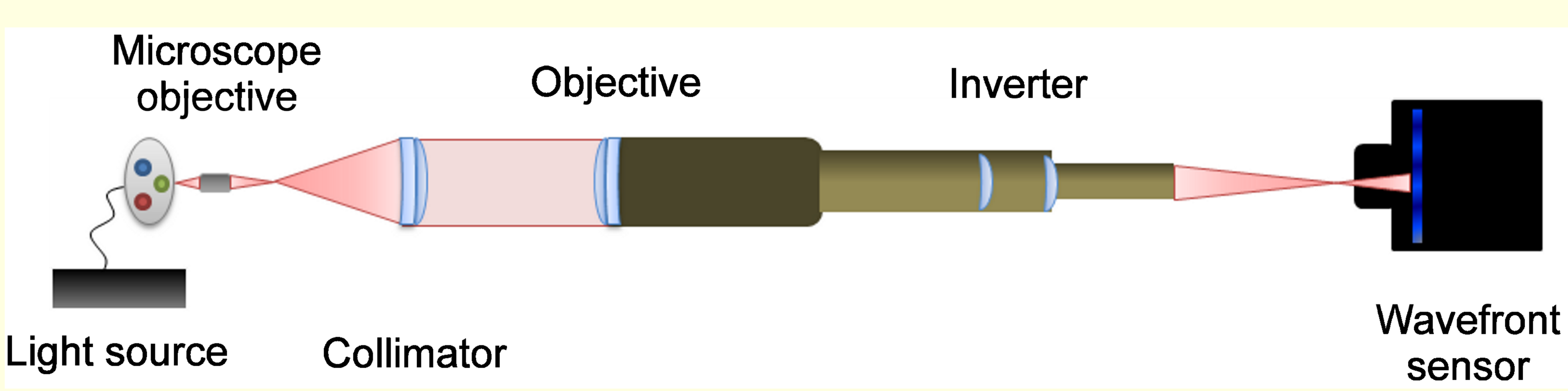
Computational implementation

Diagram of the experimental and computing procedure for obtaining the PSF of an old optical instrument with Shack-Hartmann device's experimental results, and the method for obtaining a simulated image as it'd seen through the antique optical instrument.

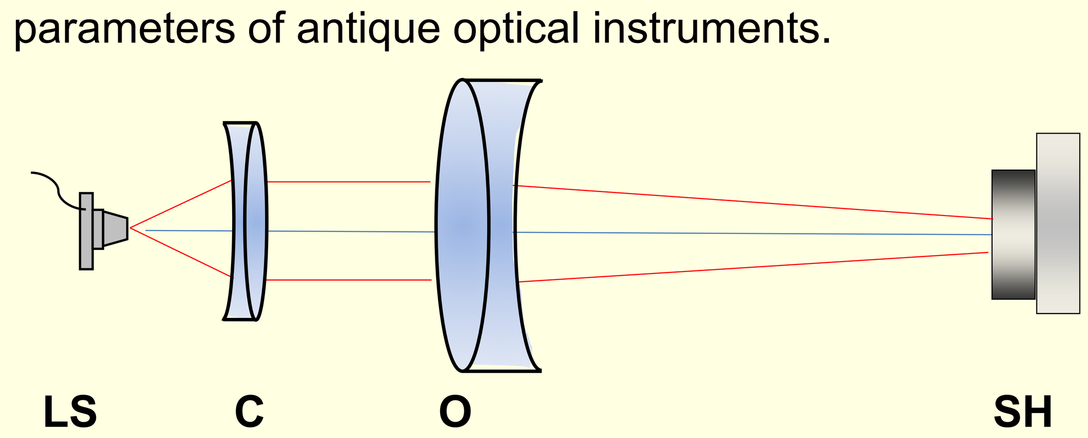


Experimental Measurements

An on-going study: Optical quality assessment and determination of geometrical parameters of antique optical instruments.

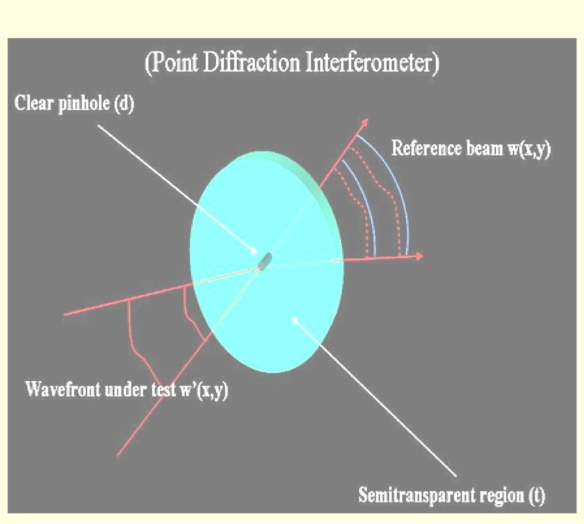


Experimental set-up for obtaining the Zernike polynomial coefficients of the aberrated wavefront by an antique optical instrument (terrestrial telescope) using a Shack-Hartmann wavefront sensor. We're going to use this method and configuration in the study of antique microscope objectives.

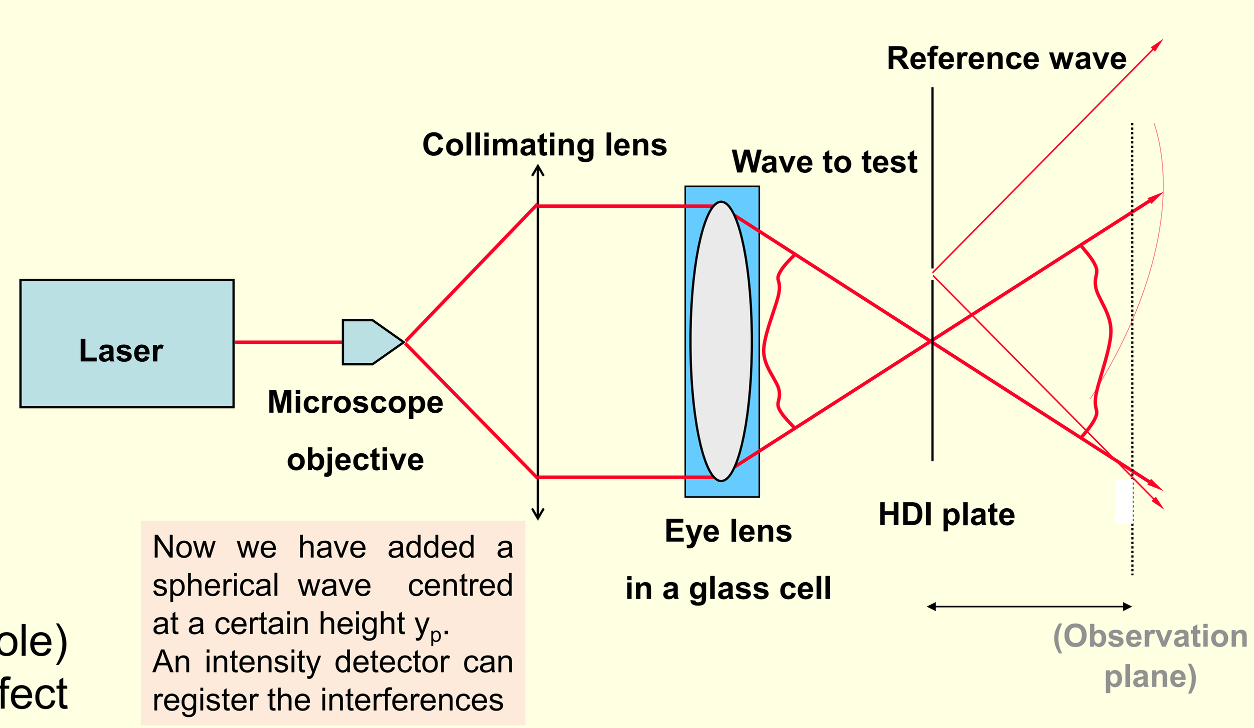


Experimental set-up for obtaining the focal distance of telescope's objectives with a very big aperture. From left to right: Light source (LS), Collimator (C), Objective (O) and Shack-Hartmann device (SH). Using this configuration we can determinate the focal length of the objective that we are studying and the refractive index of each lens that compose the objective.

Point diffraction interferometer applied on the study of crystalline fish lenses

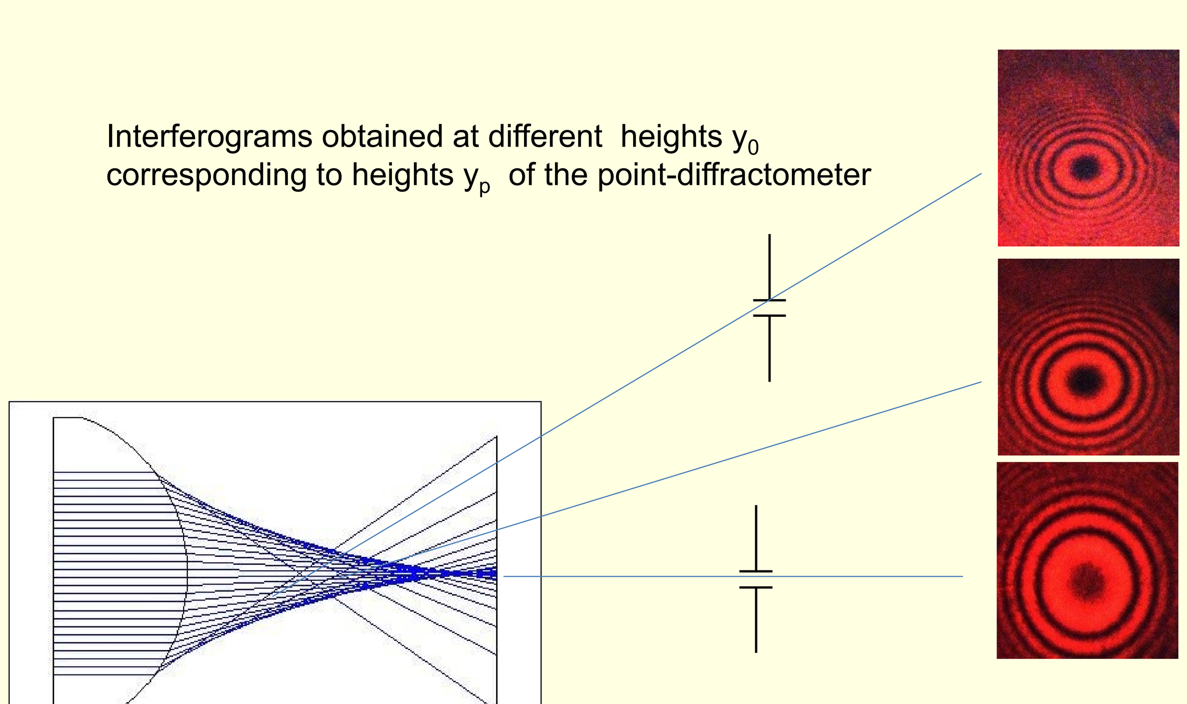


A point object (pin-hole) diffracts light into a perfect spherical wave.



Now we have added a spherical wave centred at a certain height y_p. An intensity detector can register the interferences

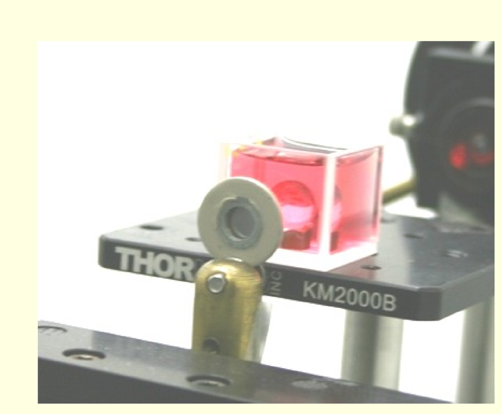
Interferograms obtained at different heights y_0 corresponding to heights y_p of the point-diffractometer



Experimental Measurements: Fish eye crystalline lens

An on-going study: Fish eye crystalline lens measurement. The optical properties of the isolated crystalline lens determine its precise role in ocular optics.

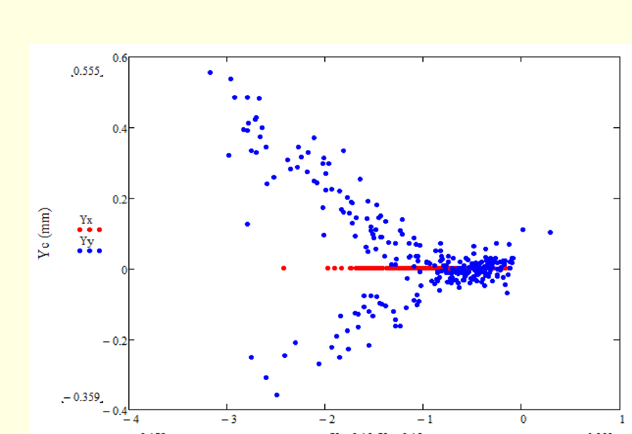
Vision of fish eyes is similar to terrestrial vertebrates like birds and mammals, but have a spherical lens. Their retinas generally have both rod cells and cone cells.

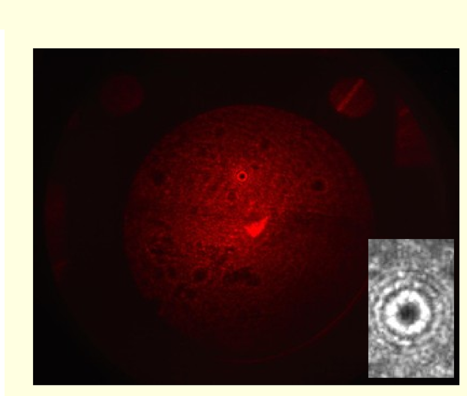


Glass cell with the crystalline lens and the point diffraction plate.

Crystalline lens under test: Scorpion fish (*Scorpaena Scrofa*)

Caustics computed from the first dark fringe





Noisy interferogram with some visible fringes.

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