PUPIL ENGINEERING FOR INCREASED TOLERANCE TO SPHERICAL ABERRATION

[(1)]I. Escobar , [(1)]C. Ibáñez-López, [(1)]G. Saavedra, [(2)]J. Lancis, [(1)]P. Andrés, and [(1)]M. Martínez-Corral

[(1)]Departamento de Óptica, Universidad de Valencia, E46100 Burjassot, Spain.
[(2)] Departamento de Ciencias Experimentales, Univ. Jaume I, E12080, Castellón, Spain.
E-mail: genaro.saavedra@uv.es

KEYWORDS: Scanning microscopy, spherical aberration, high-NA apodization.

In optical microscopy high spatial resolution is usually achieved by use of high-NA oil immersion objective lenses. In practice, the refractive index of biological samples does not match the one of the immersion oil. Consequently, when imaging deep inside the specimen, an important amount of spherical aberration is introduced. Such an aberration appears also as a result of the transmission of light through the subsequent interfaces existing between the sample and the objective. Since this problem has been known since long time ago, the good-quality high-NA objectives incorporate a correction collar. However, when imaging 3D samples, the use of this collar permits the correction for the spherical aberration only for a given section of the sample. Consequently, the design of pupil elements that increase the tolerance of the system to the spherical aberration is of great interest.

On the basis of the propagation properties of the second-order moment of the axial intensity distribution, we have designed a spherical-aberration tolerance (SAT) pupil filter. The resulting, purely absorbing, element confers on the system an important robustness against the induced spherical aberration. In Fig. 1, we show the results of a numerical experiment in which we test the imaging performance of the filter. In Fig. 2 we present the results of a preliminary microscopy experiment.

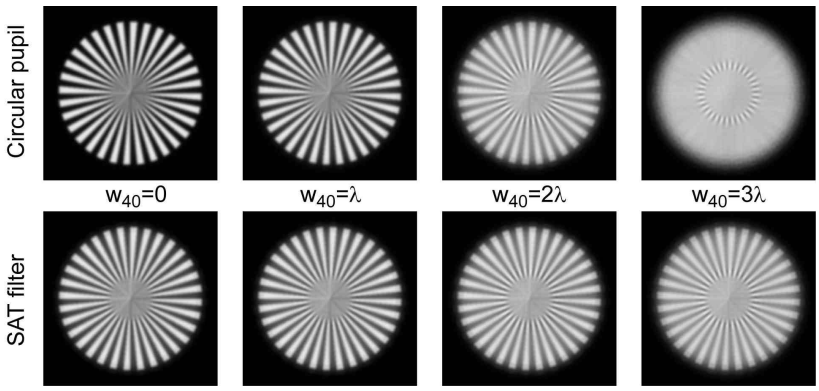

Fig. 1.- Numerically evaluated images of a typical spoke target, for different amount of spherical aberration. The SAT filter is annular, purely-absorbing without any phase variation.

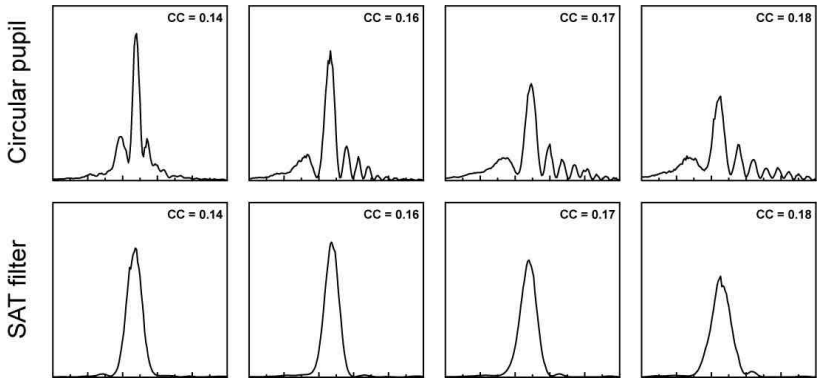

Fig. 2.- Experimental measurements for the response to an axially-scanned planar reflector. The experiment was performed with a 1.2 NA water-immersion objective and four different adjustments for the correction collar (CC).

The work was funded by the grant DPI2003-4698, Ministerio de Ciencia y Tecnología, Spain.