ISOTROPIC FOCUSING WITH A SINGLE OBJECTIVE LENS:
“ISO MICROSCOPY”
Eric Le Moal, Emeric Mudry, Patrick C. Chaumet, Patrick Ferrand, Anne Sentenac
Institut Fresnel, Campus de St Jérôme, 13013 Marseille, France
E-mail : eric.le-moal@fresnel.fr

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Focusing a light beam through a lens produces an anisotropic spot elongated along the optical axis, because the light comes from only one side of the focal point. This anisotropy is a strong handicap for microscopy, as it limits the spatial resolution along the optical axis direction. The best option to date for improving the axial resolution consists in employing two opposing lenses and coherent illumination to create a total wavefront that comes closer to a complete spherical wavefront. The so-called 4Pi microscopy has provided impressive results of 3D imaging with quasi isotropic spatial resolution. [1]

Using the time-reversal concept, we showed that isotropic focusing at the diffraction limit can also be achieved using one single objective lens by placing a mirror after the focal point and shaping the incident beam to have part of the incident and reflected fields converging to the same point. We developed a 3D imaging system implementing that technique, based on a confocal microscope and a phase-only spatial light modulator, with the aim of bringing about a 3-fold improvement of the axial resolution [2]. Numerical results as well as experimental measurements of point spread functions are presented. Conditions for practical implementation in a confocal microscopy system and possible alternative to wavefront shaping are discussed.

Figure 1: Left: Experimental setup; Right: Axial and transverse slices of a 3D image of a fluorescent bead (experimental and calculated). From Ref. [2].