

# Fourier plane filtering, Riesz transforms, and Singularities in Optics

*Bettina Heise, Stefan E. Schausberger, David Stifter, Erich P. Klement*

CDL MS-MACH, FLLL, ZONA, Johannes Kepler University Linz,

Austria

Nowadays harmonic analysis and wavelet-based decomposition approaches play an important role in image processing naming applications as image denoising, segmentation, or compression methods among others. In particular, analytic or monogenic wavelet approaches have found entrance in image processing delivering additional phase and orientation information or may be used for scale-based demodulation [1, 2].

What is less known is the fact that similar approaches exist in optics, at least to a certain extend. High, band, or low pass filtering can be performed analogously in an optical way. Furthermore, also Hilbert and Riesz transform build up the basis for some filtering approaches, usable for isotropic or anisotropic contrast improvement [3, 4], for orientation emphasising, or for salient point detection. Fractional spiral phase filter described mathematically by a Riesz transform-based filter kernel as well as cone-like monogenic phase filter, resembling monogenic curvelet approaches, for a steerable contrast modification should be mentioned [5, 6].

We will discuss similarities, differences, and restrictions for harmonic analysis and filtering approaches in imaging and image processing and argue their partially different behaviour.

[1] M. Storath, Directional Multiscale Amplitude and Phase Decomposition by the Monogenic Curvelet Transform, *SIAM J. IMAGING SCIENCES* 4 (2011) 57–78.

[2] M. Unser, D. Sage, D.V.D. Ville, Multiresolution monogenic signal analysis using the Riesz-Laplace wavelet transform, *IEEE Trans. Image Proc.* 18 (2009) 2402-2418.

[3] S. Fürhapter, A. Jesacher, S. Bernet, and M. Ritsch-Marte, Spiral phase contrast imaging in microscopy, *Opt. Express* 13, (2005) 689–694.

[4] S.E. Schausberger, B. Heise, C. Maurer, S. Bernet, M. Ritsch-Marte, D. Stifter, Flexible contrast for low-coherence interference microscopy by Fourier-plane filtering with a SLM, *Opt. Lett.* 35 (2010) 4154-4156.

[5] B. Heise, S.E. Schausberger, D. Stifter, Coherence Probe Microscopy: Contrast Modification and Image enhancement, *Imaging & Microscopy* 2 (2012) 29-32.

[6] G. Situ, G. Pedrini, W. Osten, Spiral phase filtering and orientation-selective edge detection/enhancement, *J. Opt. Soc. Am. A* 26 (2009), 1788-1797.