LABEL-FREE WIDEFIELD NANOSCOPY BELOW 100NM RESOLUTION WITH CONVENTIONAL OPTICS

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ABSTRACT: Label-free nanoscopy encompasses optical imaging with resolution in the 100nm range using light. This regime has been a great challenge due to the lack of non-linear effects, which have permitted nanoscopic resolution in fluorescence-based nanoscopy [1]. In label-free imaging, the Abbe limit relating resolution Δx with imaging wavelength and numerical apertures ($n \sin(\alpha)$) of objective and condenser lenses is still unbroken:

$$\Delta x = \frac{\lambda}{n_o \sin(\alpha_o) + n_c \sin(\alpha_c)}.$$

Previous approaches for label-free imaging nearing 100nm resolution focussed on increasing the refractive index n_c of the condenser immersion medium via photonic waveguides featuring extraordinarily large refractive indices and intrinsically perpendicular illumination ($\alpha_c = 90°$) [2,3]. Although thus realising close to 100nm resolution, several limitations are associated with these approaches, major ones being the requirement of custom manufactured waveguide photonic chips and the severely restricted field of view.

I will present how conventional optical elements can achieve similar and even better resolution. Key in this respect is a change of wavelength to the ultra-violet (266nm by a frequency quadrupled Nd:YAG). Despite the highly restricted choice of transparent glasses in the UV range, which rules out normal objectives, a *catadioptric* combination of a solid immersion aplanatic lens with a finite conjugate reflective objective exists that features controllable aberrations at a greatly increased numerical aperture in comparison to the reflective objective on its own. Intriguingly, this numerical aperture can be realised for both condenser and objective lens, which is in contrast to previous approaches.

As obstacles of this concept are plentiful in theory and practice, ranging from aberration treatment, tight tolerances, sample and aplanatic lens mounting as well as photo-toxicity, I will discuss practical solutions and present a respective system design, detailed aberration analyses, and a suitable image-processing pipeline to enable a theoretical resolution below 100nm in simulations as well as initial experimental results.

REFERENCES

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