Superresolution by Spatial Demultiplexing

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In the last decades, a number of techniques for circumventing the diffraction limit in microscopy have been proposed, defining a field called superresolution imaging. However, these approaches involve active interaction with the sample: they are either operational in the near-field only, or rely on non-linear probing, which makes them expensive, invasive, and not universally applicable. But can we achieve superresolution by observing light coming from an object without any active interaction with it?

Although the diffraction limit had been known for 150 years and appeared unsurmountable, recent advances in quantum optics showed that it can in fact be beaten by extracting further information about the incoming field: not just the intensity distribution in the image plane as in conventional direct imaging, but the correlation of electromagnetic field amplitudes at different transverse positions [1]. In practice, this involves demultiplexing the incoming field into an orthonormal basis of spatial modes (*e.g.*, Hermite-Gaussian), measuring the amplitude or intensity of each basis component and subsequently reconstructing the image from these data.

The advantage of this approach over direct imaging was experimentally tested in recent years. Our group has proposed [2] and realised [3,4] a proof-of-concept experiment on SpaDe imaging, achieving a resolution enhancement by more than a factor of two compared to the diffraction limit. We will discuss these results and perspectives of developing then into a revolutionary imaging technology applicable in realistic conditions and at all scales, and hence capable of revolutionizing microscopy and opening new avenues for scientific and industrial applications of imaging, ranging from nanotechnology and life sciences to environmental sciences and astronomy.

References

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