Extraordinary Computational Imaging Technologies with Ordinary Optical Modulators


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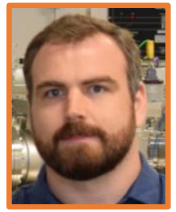

Tomas Katkus


Molong Han


Denver Linklater


Annaleise Klein

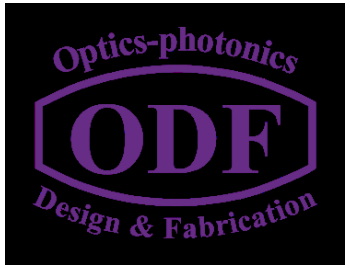

Keith Bambery


Mark Tobin


Elena Ivanova


Jitraporn Vongsvivut


Saulius Juodkazis



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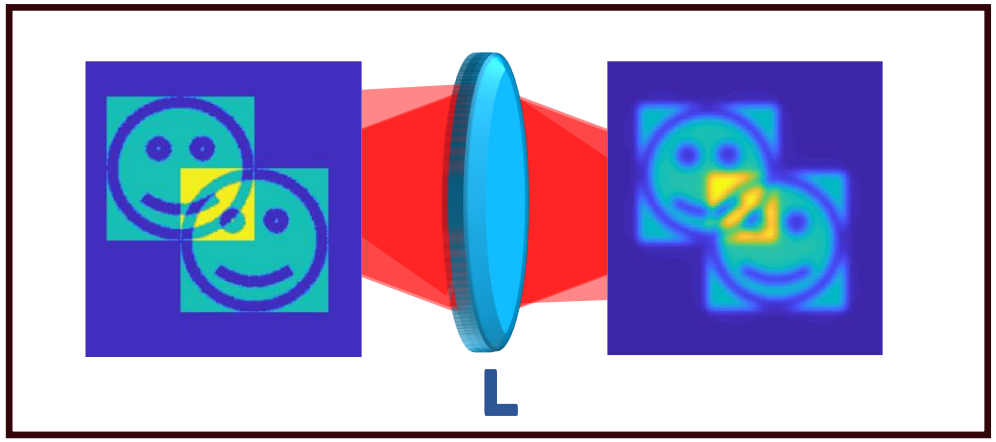
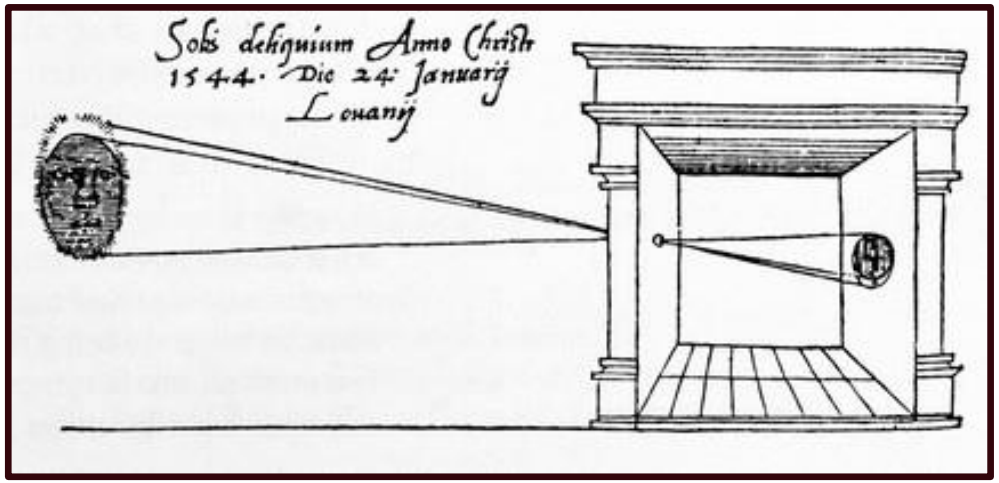
OUTLINE

- Direct incoherent Imaging method
- Fundamentals of incoherent holography
- Fundamentals of coded aperture imaging
- 5D imaging system
- 3D Infrared imaging system
- 3D synchrotron imaging system
- Conclusion

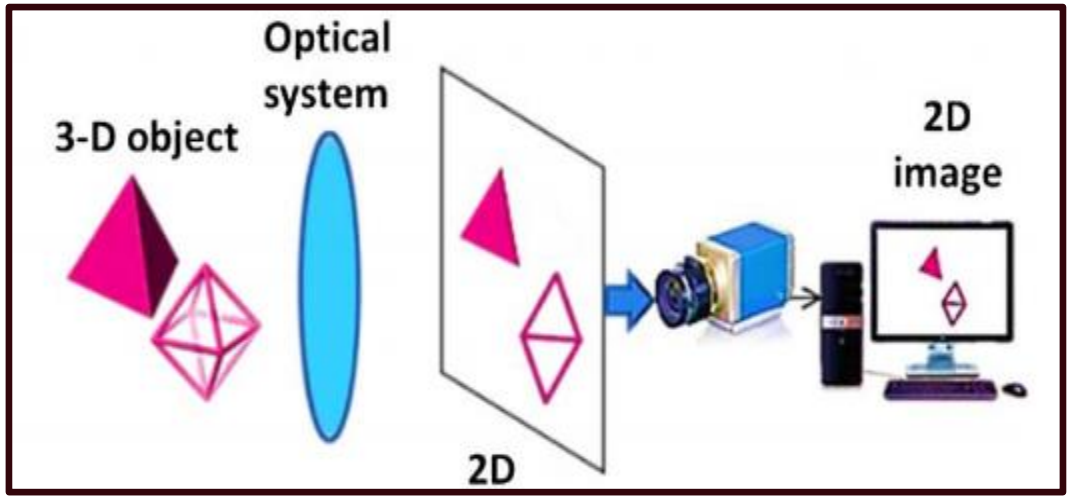
Direct imaging methods



An incoherent imaging system is linear in intensity.



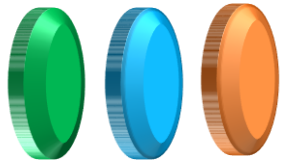
Gemma Frisius' 1545 book De Radio Astronomica et Geometrica



Two-dimensional representation of 3D object

Commercial systems

Imaging capabilities



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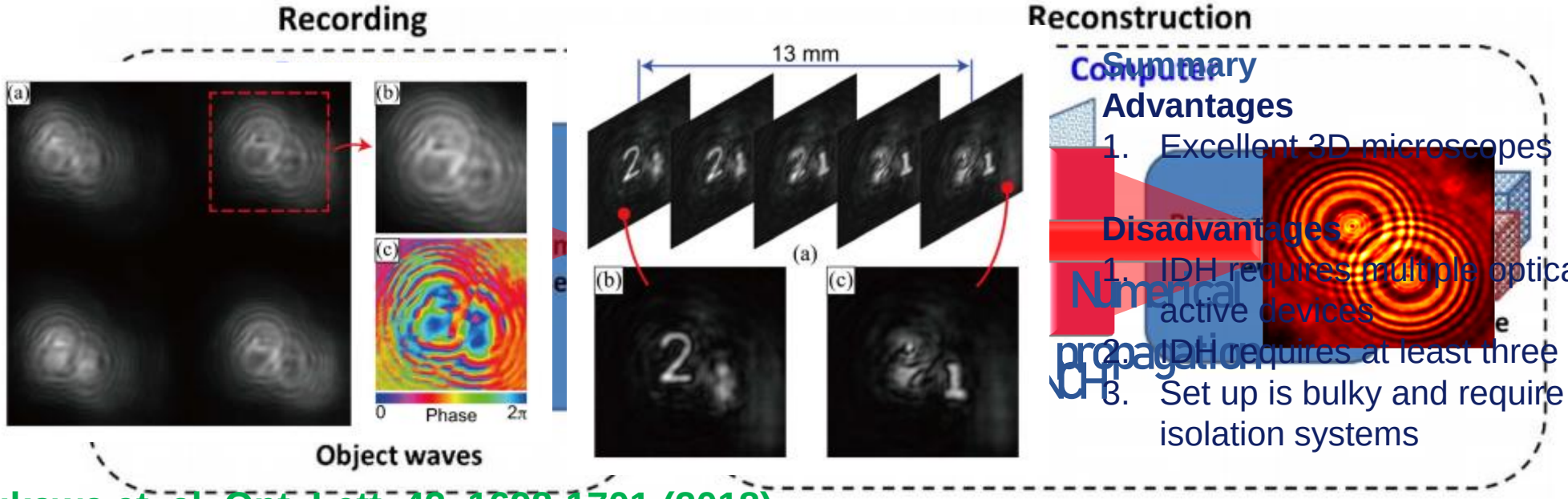
Fundamentals of incoherent holography



Summary

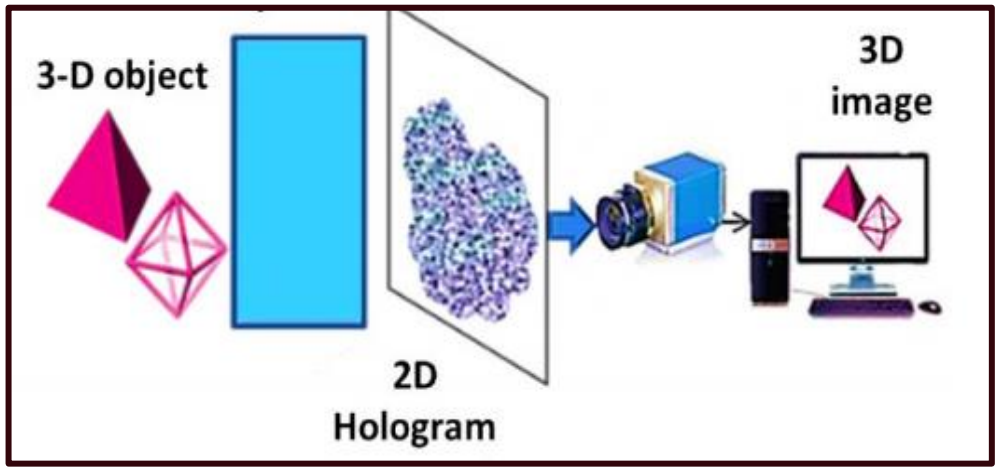
Advantages

1. Excellent 3D microscopes

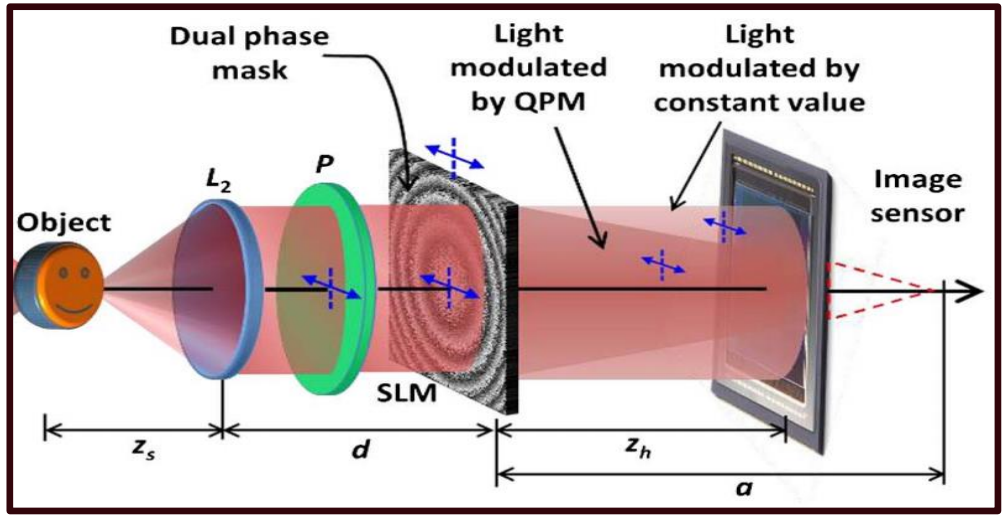
Disadvantages

1. IDH requires multiple optical elements, active devices
2. IDH requires at least three camera shots
3. Set up is bulky and require vibration isolation systems

Nobukawa et. al. Opt. Lett. 43, 1698-1701 (2018).



Rosen, et. al. Adv. Opt. Photon. 11, 1-66 (2019).



J. Rosen and G. Brooker, Opt. Lett. 32, 912-914 (2007).

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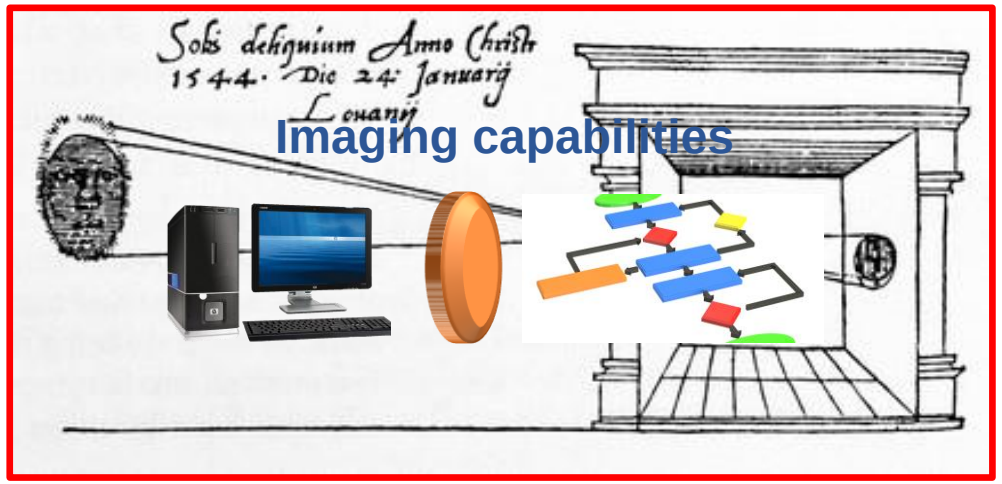
Fundamentals of coded aperture Imaging



Imaging capabilities

Gemma Frisius' 1545 book De Radio Astronomica et Geometrica

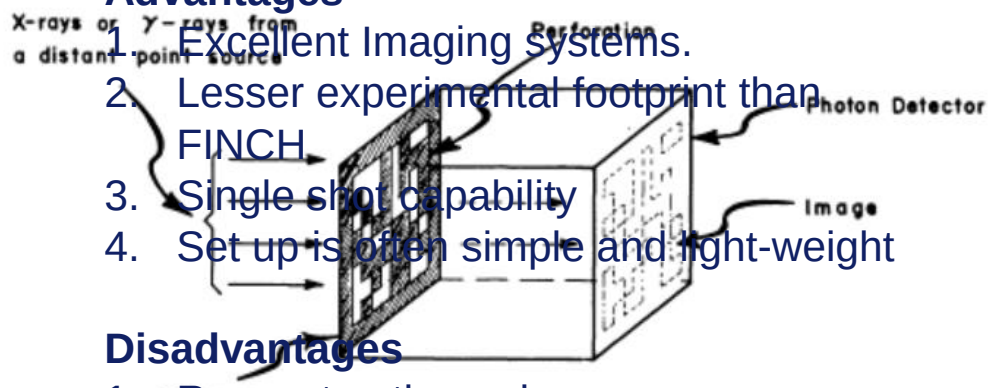
Summary

Advantages

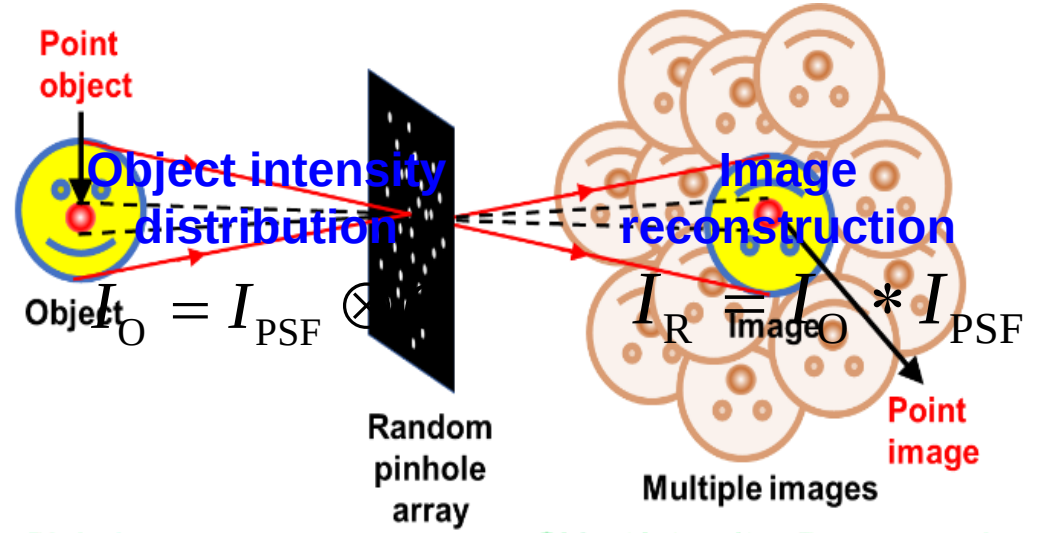
1. Excellent Imaging systems.
2. Lesser experimental footprint than FINCH
3. Single shot capability
4. Set up is often simple and light-weight

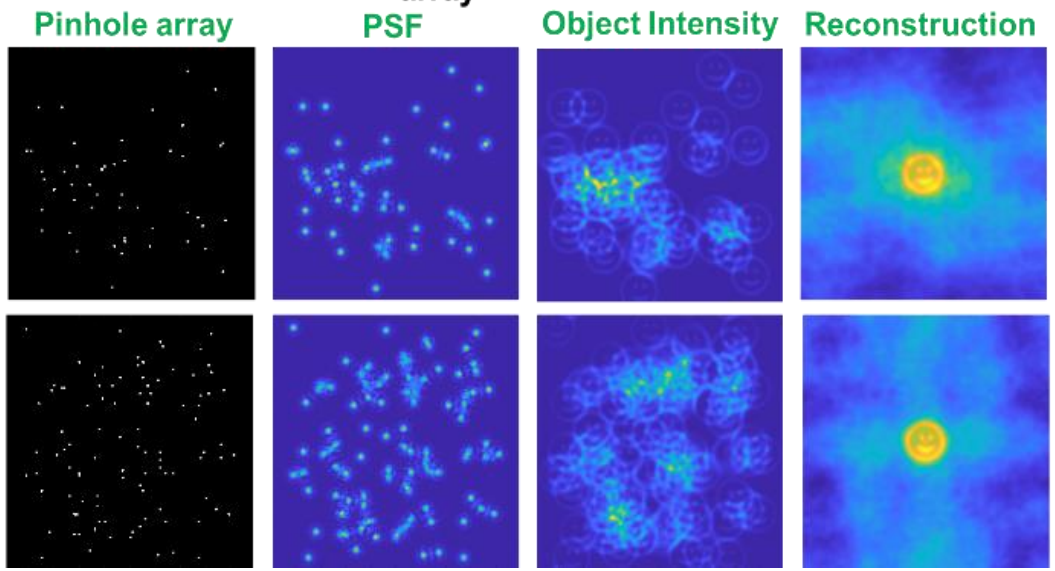
Disadvantages

1. Reconstruction noise
2. Low SNR
3. Need to record PSF



Dicke, Astrophysical Journal, vol. 153, p.L101 (1968)





V. Anand and J. Rosen, Photonics spectra Magazine March 2020

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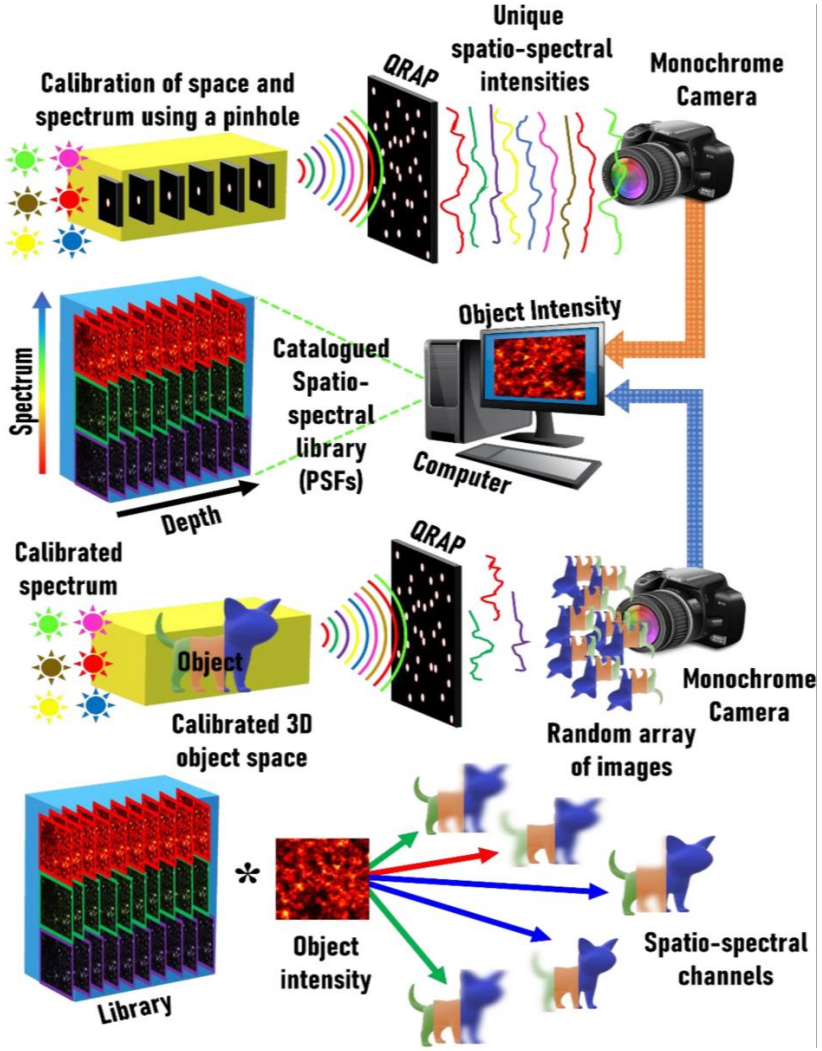
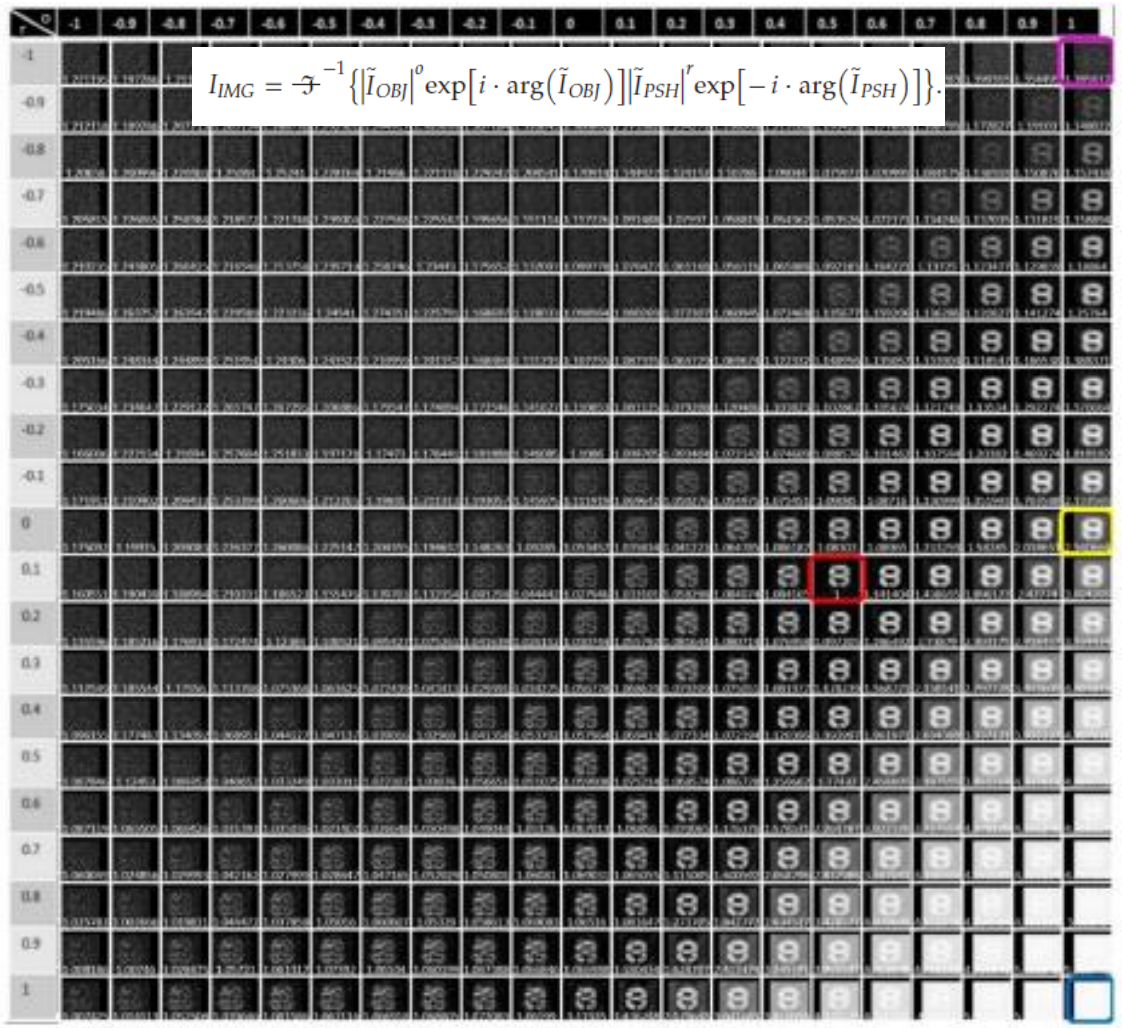
5D imaging system





Anand, V., Ng, S., H, Maksimovic, J., Linklater, D., Katkus, T., Ivanova, E., P., and Juodkazis, S., Scientific reports, 10(1), 1-13 (2020).

Mani R Rai, A Vijayakumar, and Joseph Rosen, Opt. Express 26, 18143-18154 (2018)

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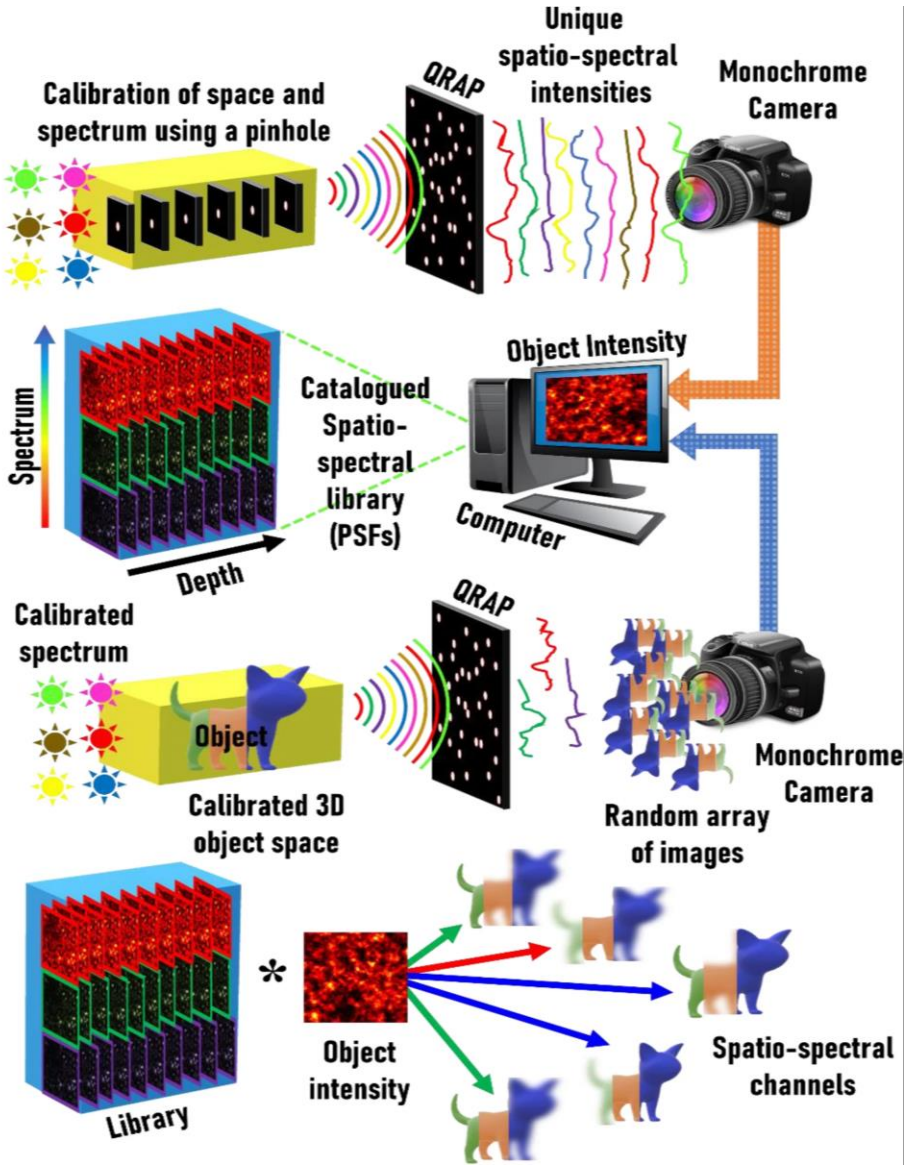
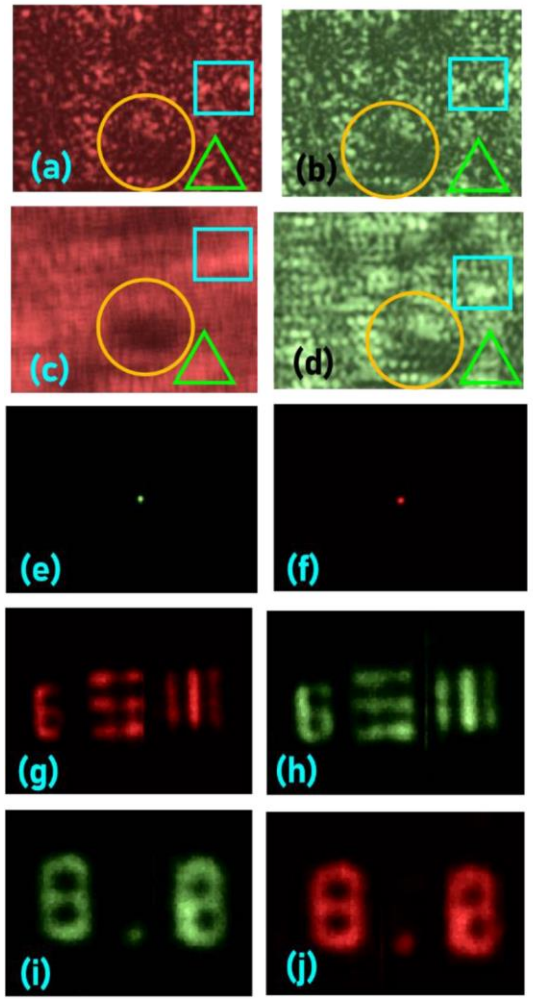
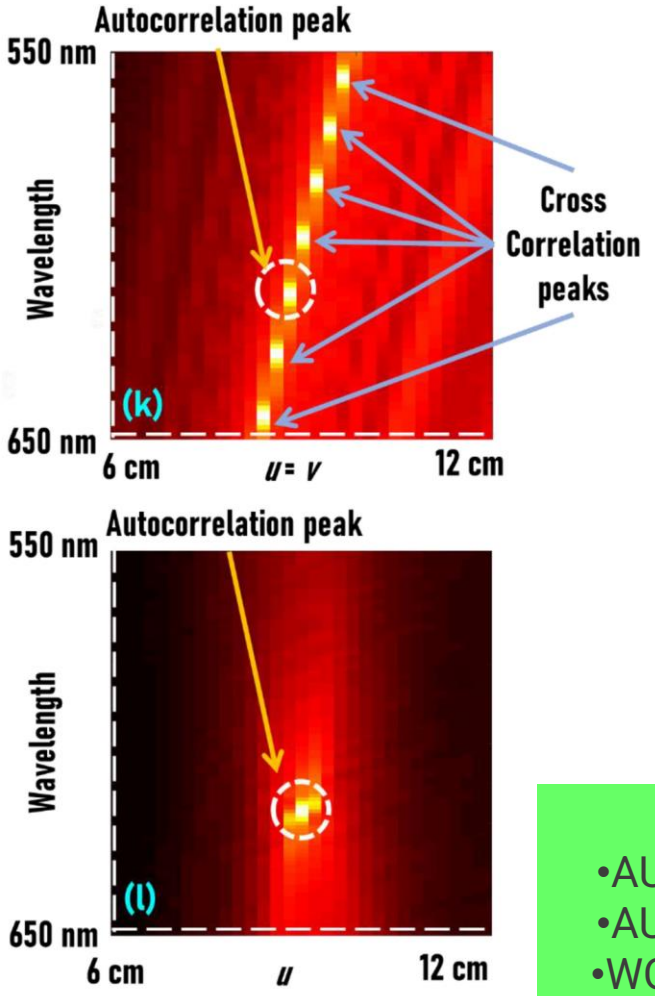
5D imaging system







Patents
- AU2019904895
- AU2020051410
- WO2021127726

Anand, V., Ng, S., H, Maksimovic, J., Linklater, D., Katkus, T., Ivanova, E., P., and Juodkazis, S., Scientific reports, 10(1), 1-13 (2020).

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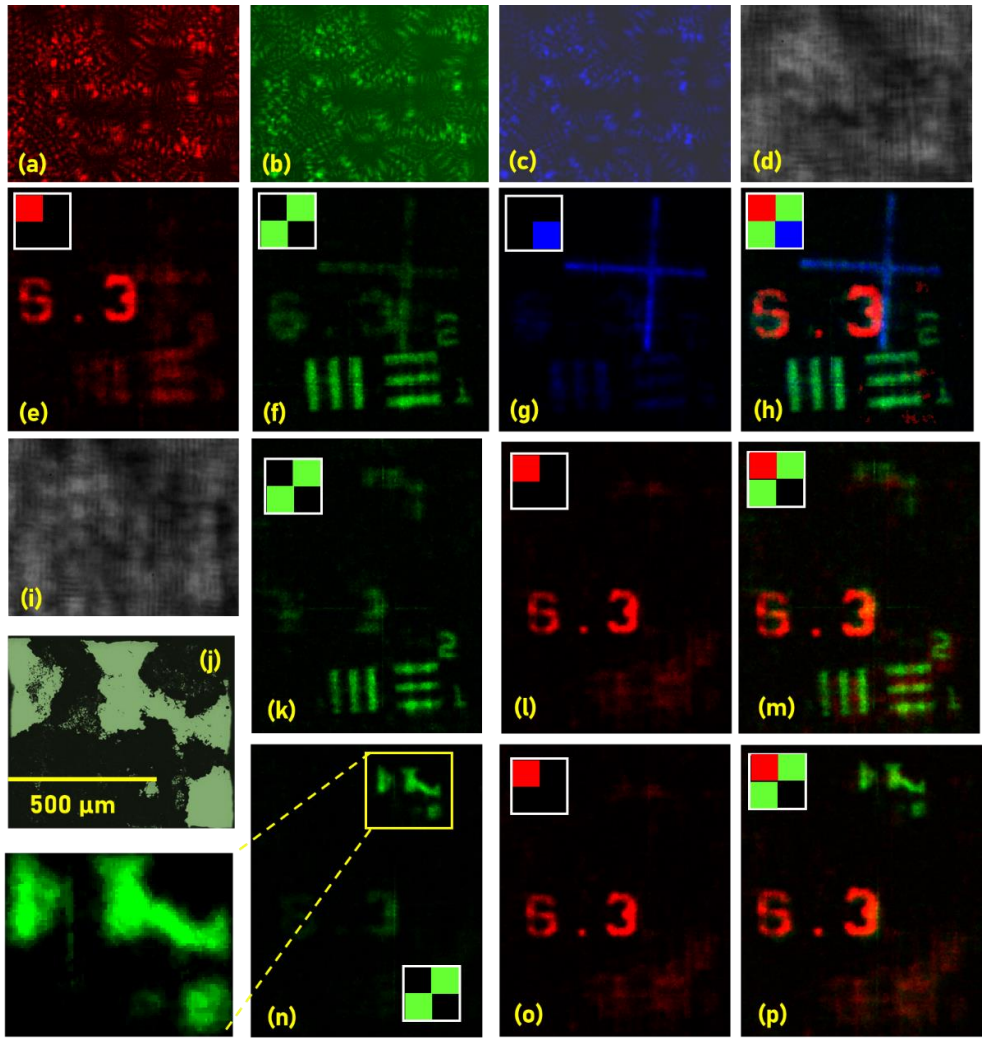
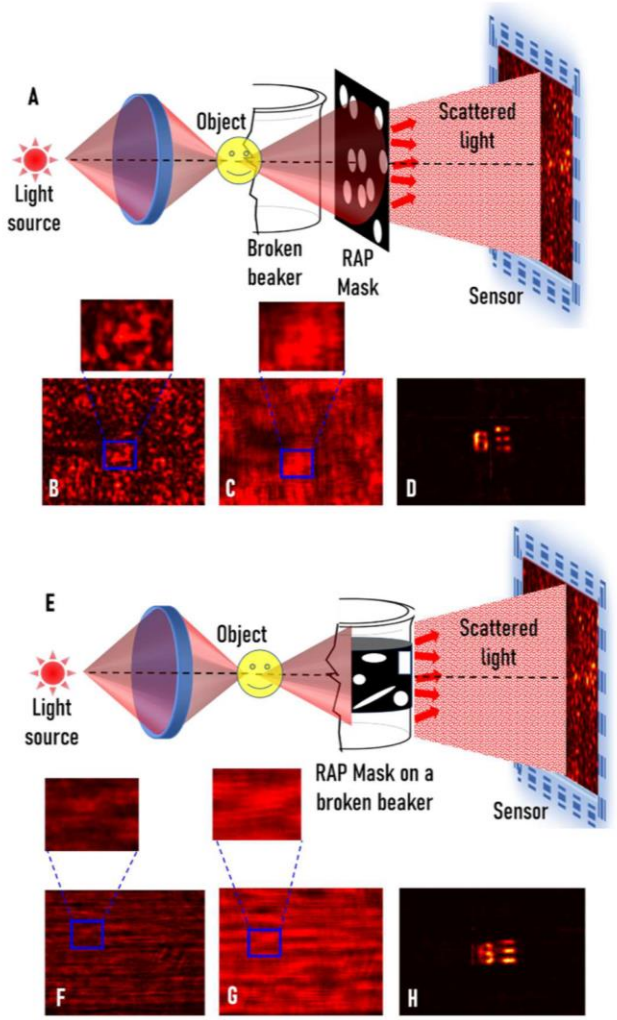
5D imaging system





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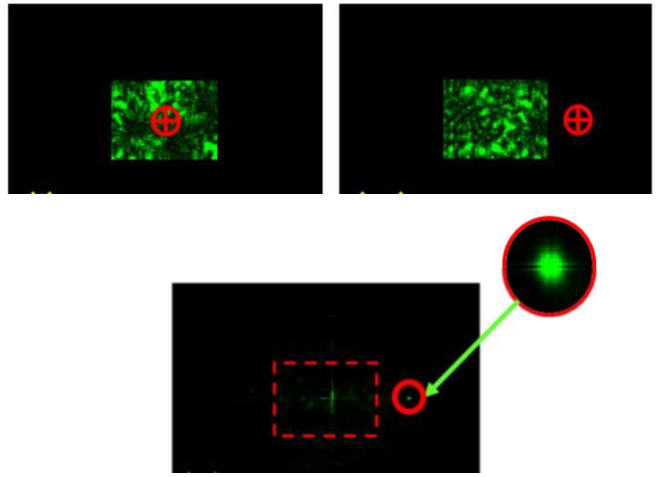
Extension of field of view



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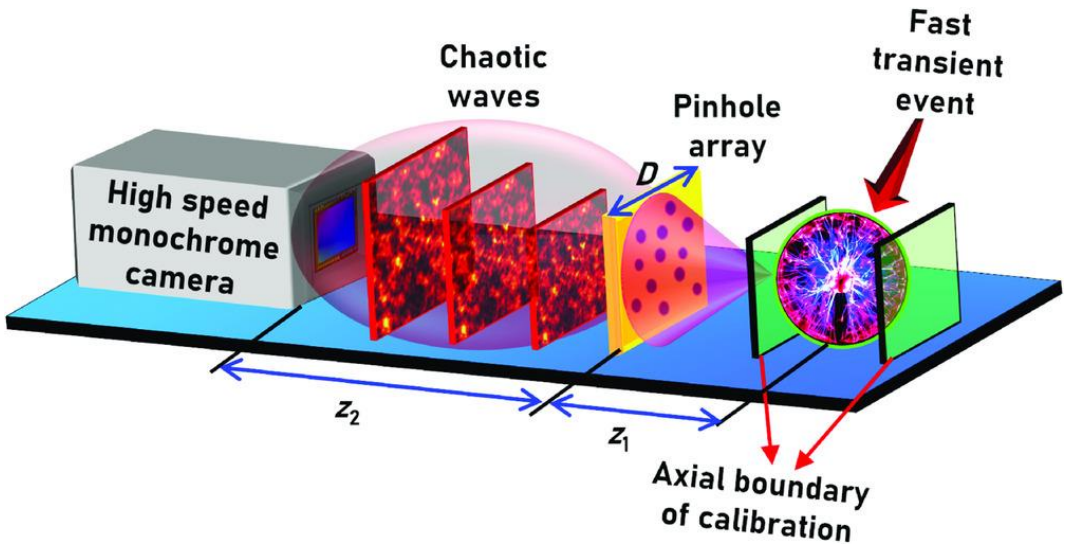
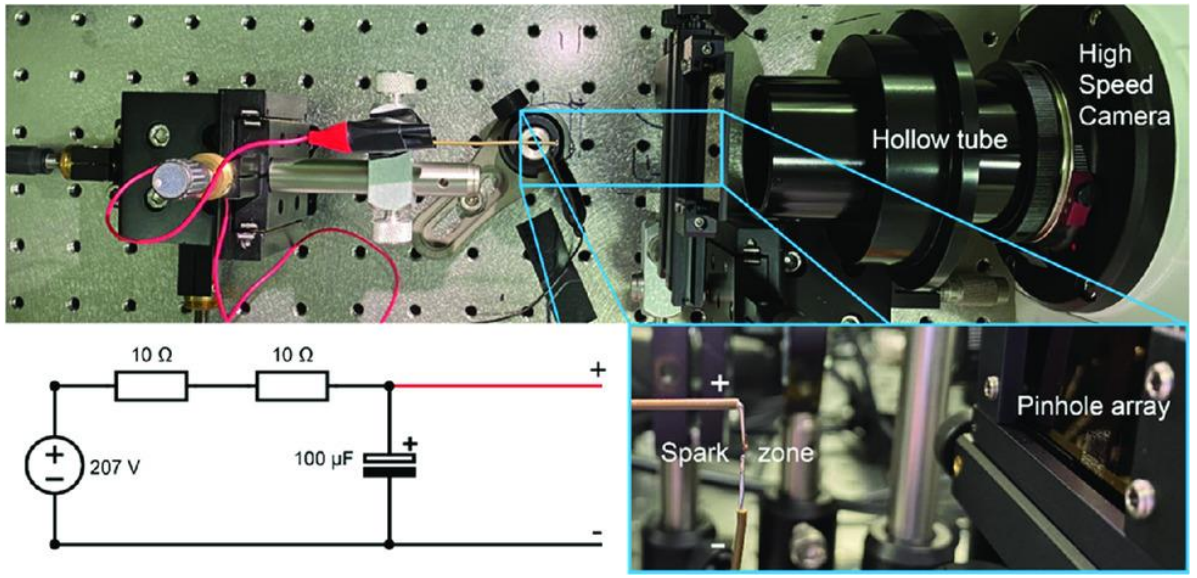
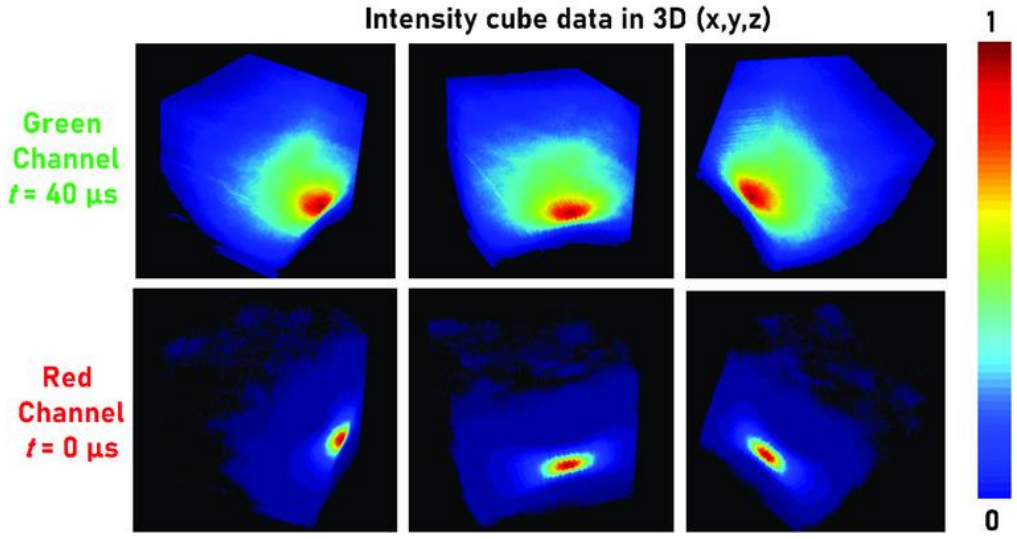
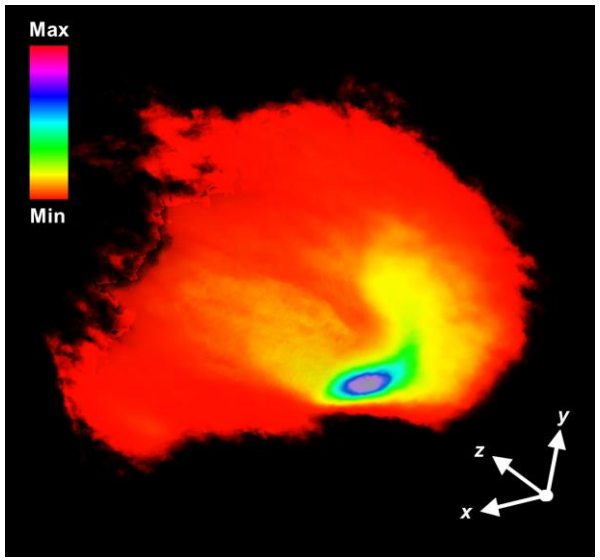
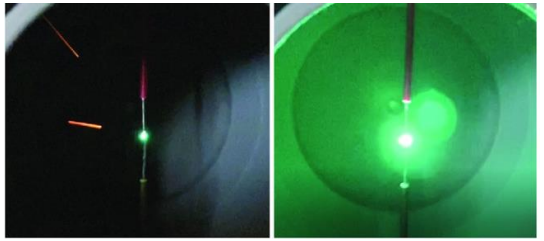
High-speed 5D imaging system











V. Anand, Soon Hock Ng, Tomas Katkus and Saulius Juodkazis Advanced Photonics Research 2.2 (2021): 2000032.

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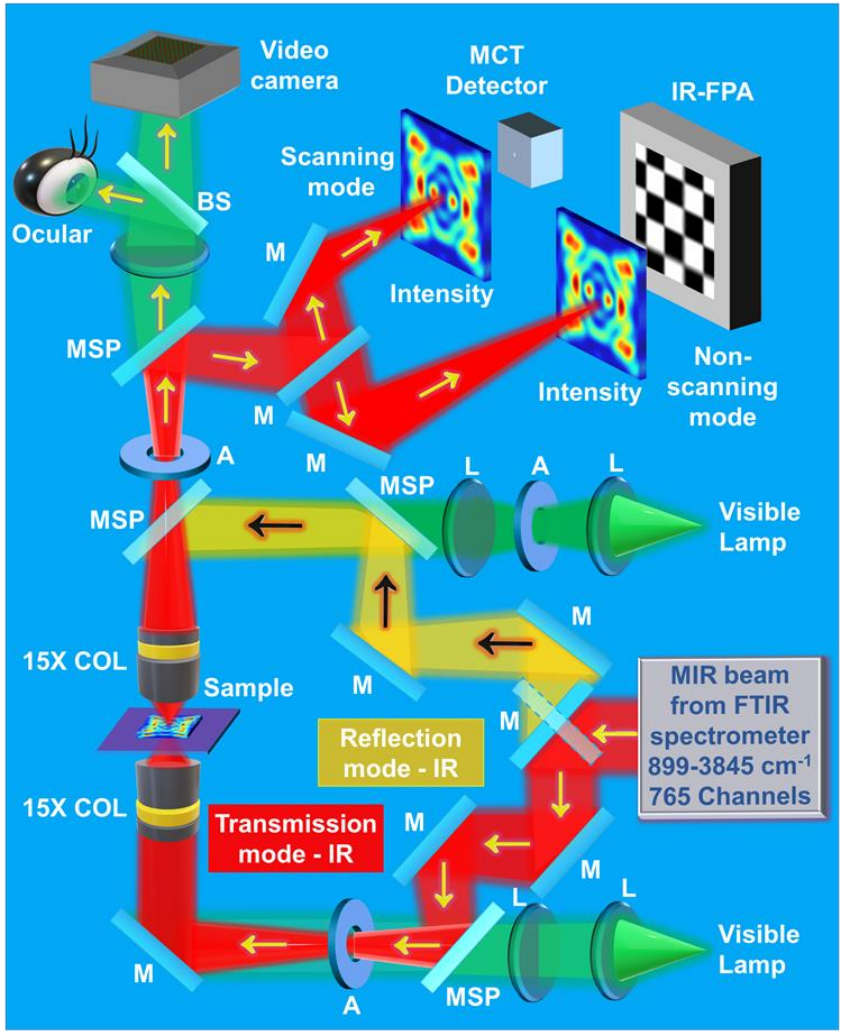
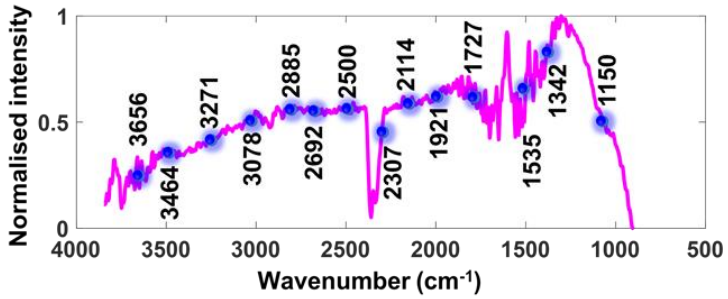
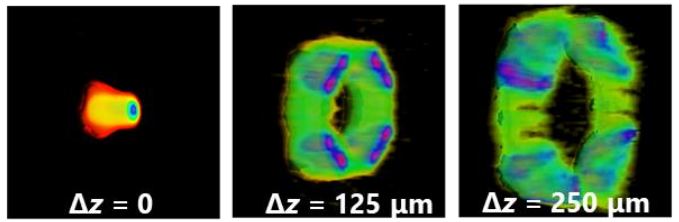
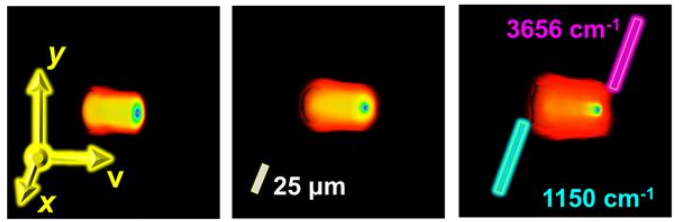
3D infrared imaging system



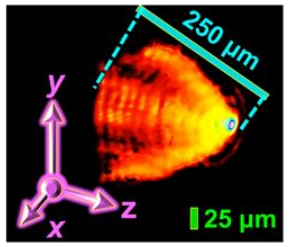




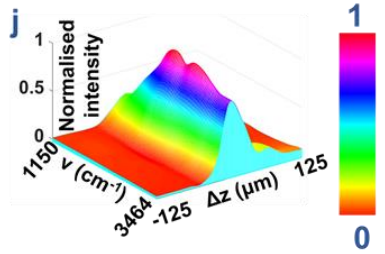
Direct PSF



Indirect PSF - Autocorrelation



3D PSF



3D autocorrelation

https://phys.org/news/2022-04-infrared-microspectroscopy-lucy-richardson-rosen-reconstruction-method.html

Anand V, Han ML, Maksimovic J, Ng SH, Katkus T et al. *Opto-Electron Sci* **1**, 210006 (2022) .
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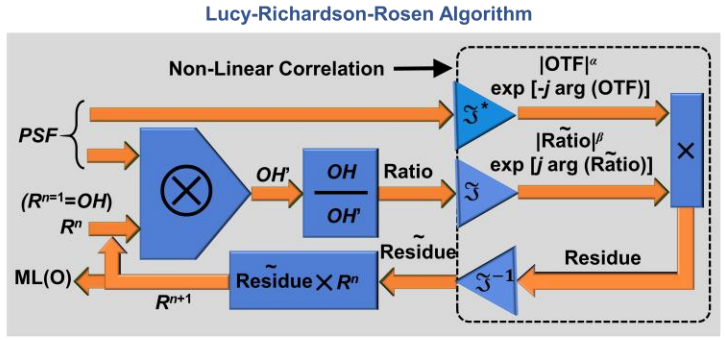
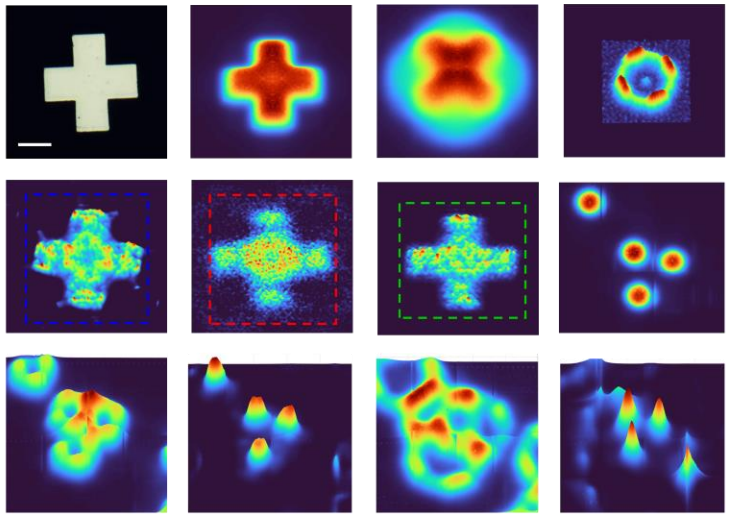
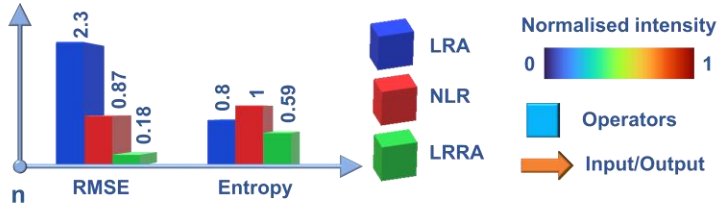
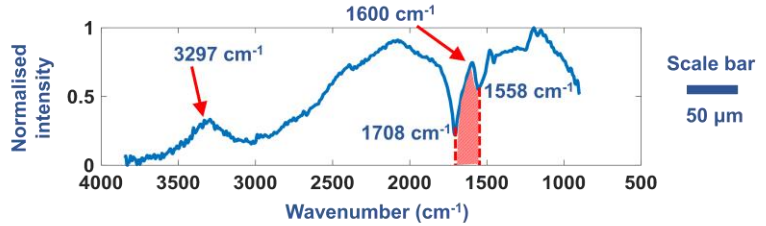
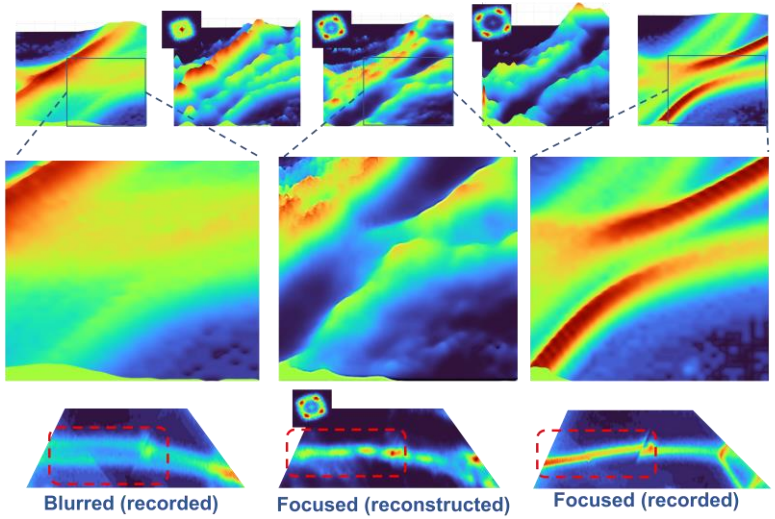
3D infrared imaging system

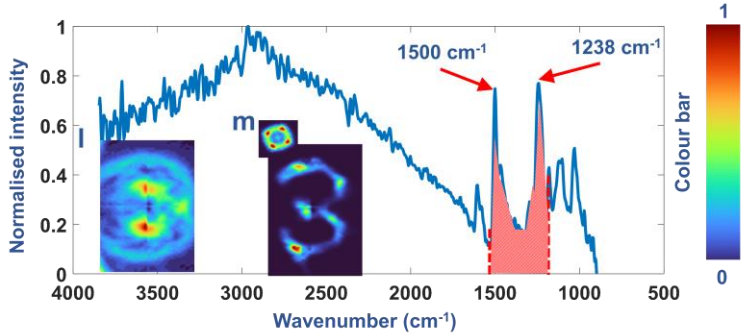


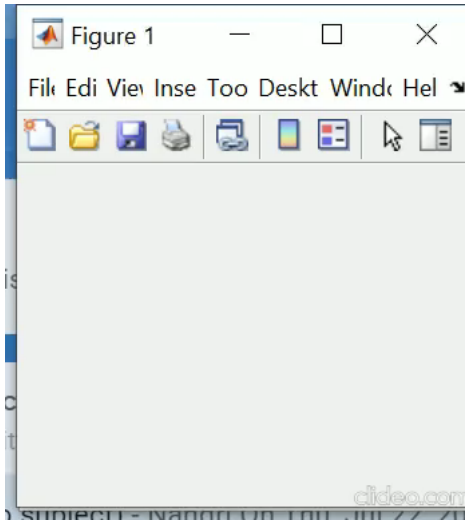


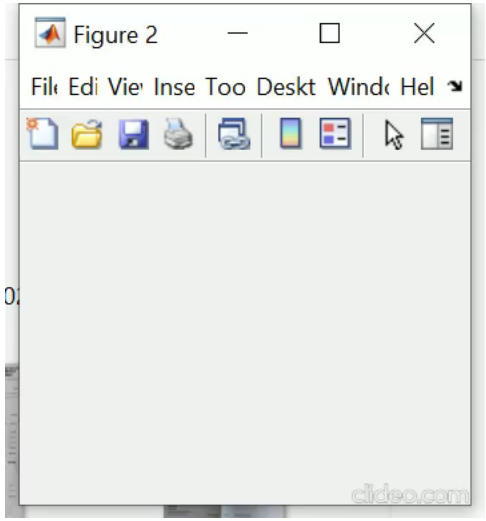












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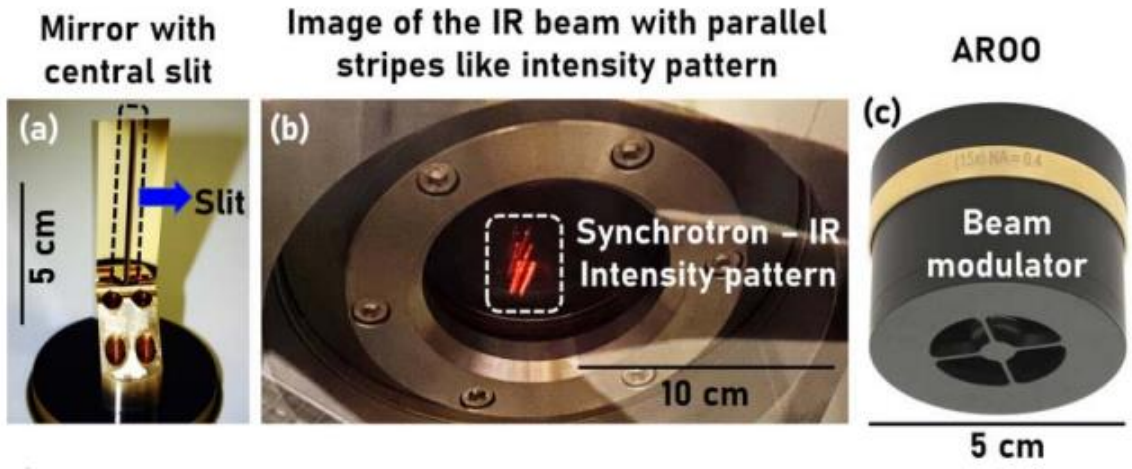
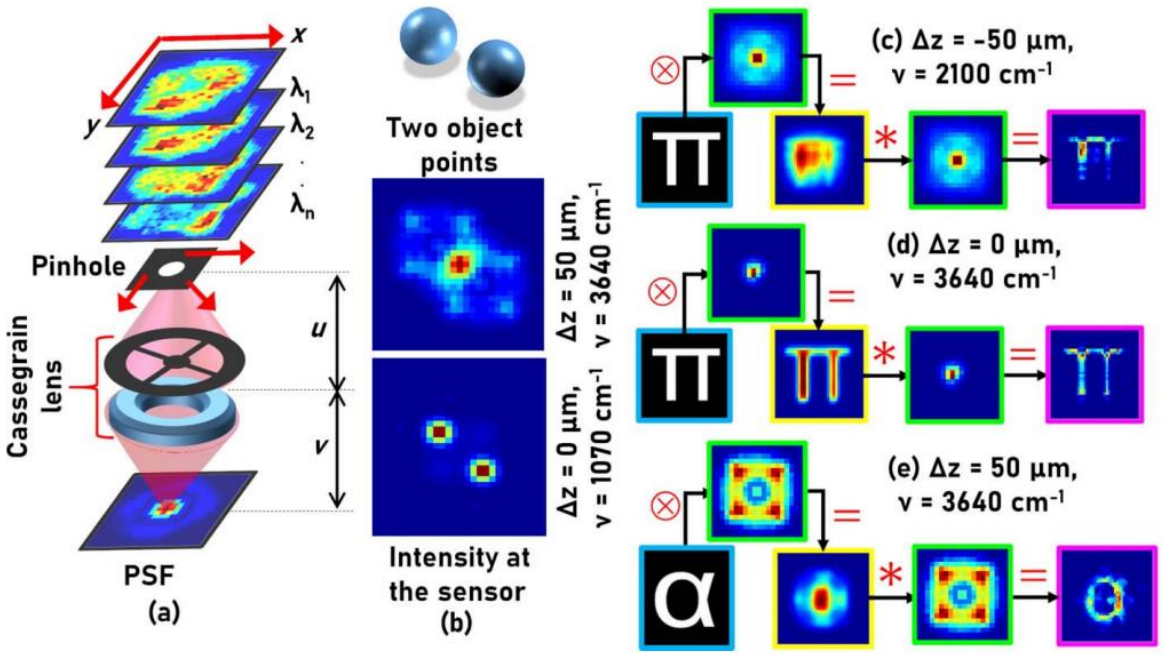
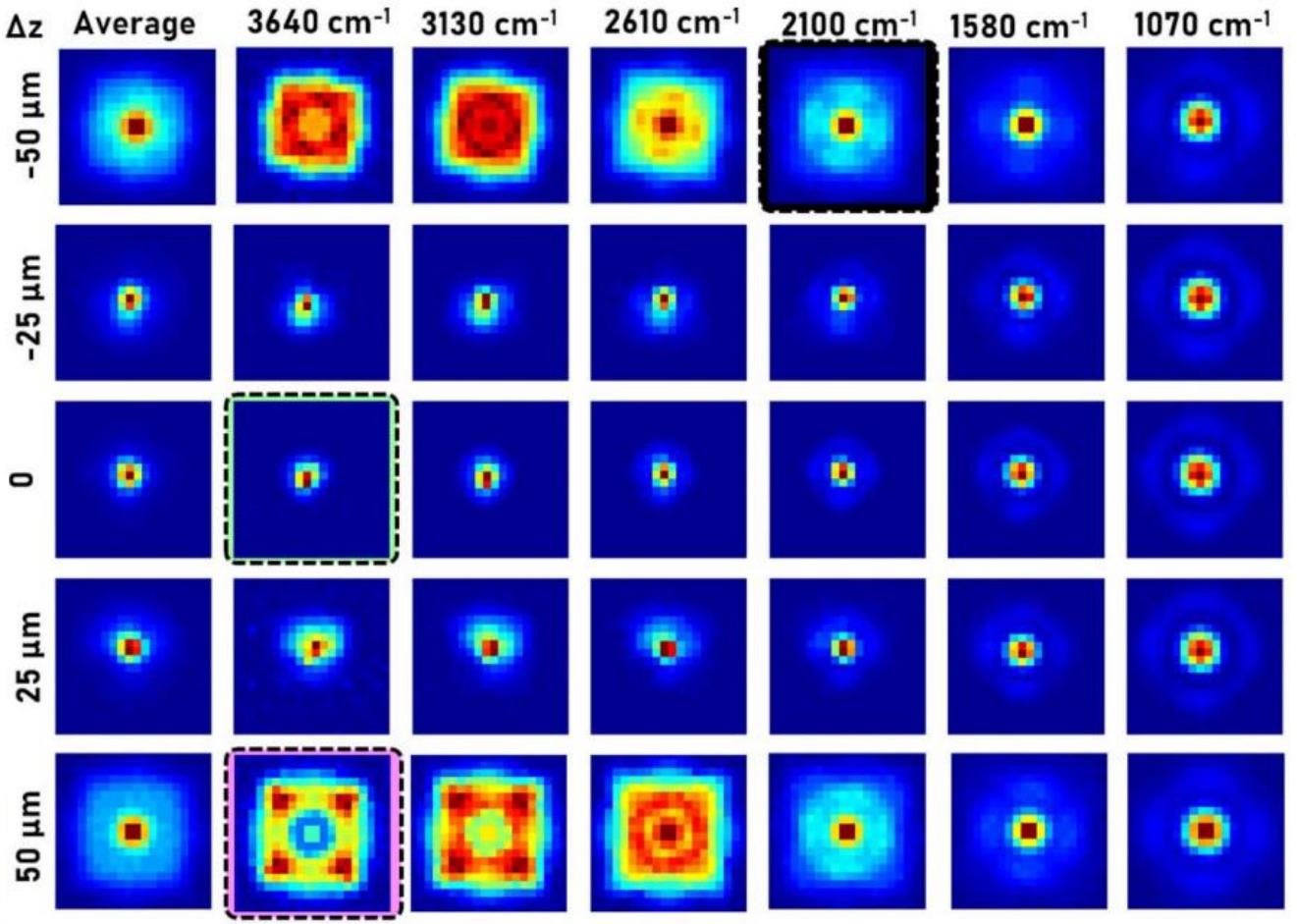
3D synchrotron imaging system







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Conclusions

- Computational imaging is a rapidly evolving area revolutionizing all areas of imaging such as microscopy, telescope, quantitative phase imaging and tomography.
- Computational imaging techniques enables ordinary optical modulators for extraordinary imaging.
- Random pinhole array has been applied for 5D imaging.
- Cassegrain objective lenses have been applied for 3D imaging.
- Advanced technology at a low cost!!!

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Questions ???

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