Acoustic light focusing for fast 3D microscopy

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How fast can we image the three-dimensional (3D) dynamics of living systems at sub-cellular resolution? The answer depends on the number of photons that we can collect from our sample. However, with continuous progress toward more sensitive and faster detectors, the rate for volumetric microscopy is becoming less constrained by the photon budget and more-so by the speed at which the focus can be moved across a sample, particularly along the optical axis (z-axis). In this talk, I will show how acoustic liquid lenses enable axial focusing at rates as high as 1 MHz. Such speed enables to rethink traditional microscopy architectures and achieve unsurpassed 3D imaging rates. I will provide two examples. First, I will discuss speed improvements in brain imaging using two-photon and confocal microscopy [1,2]. Second, I will present a novel light-sheet microscope that obviates any mechanical moving parts and is capable of characterizing moving organisms and flowing particles at several hundreds of volumes per second [3]. These results illustrate how z-focusing technologies open new avenues for characterizing key biological processes with an unprecedented detail.

[1] S. Piazza, P. Bianchini, C. Sheppard, A. Diaspro, and M. Duocastella, "Enhanced volumetric imaging in 2-photon microscopy via acoustic lens beam shaping," J. Biophotonics, **11** e201870129 (2018).

[2] T. Deguchi, G. Palazzolo, S. Surdo, S. Piazza, L. Pesce, M. Oneto, A. Diaspro, P. Bianchini, M. Duocastella, "Lissajous volumetric confocal microscopy," in preparation

[3] M. Duocastella, G. Sancataldo, P. Saggau, P. Ramoino, P. Bianchini, and A. Diaspro, "Fast Inertia-Free Volumetric Light-Sheet Microscope," ACS Photonics, **4** 1797 (2017).