COMOTION - Controlling the motion of large molecules and particles

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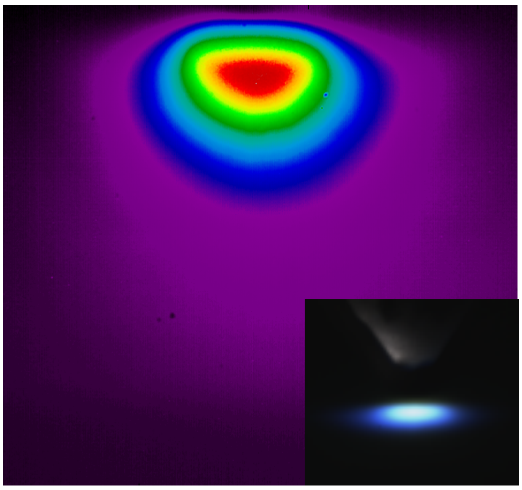
Recent years saw the development of several techniques to control small neutral molecules, and we can now routinely select single structural isomers, create beams of size-selected clusters and disperse rotational quantum states for the production of colder molecular ensembles, in certain cases even creating single-quantum-state samples [1]. Here we report on our efforts to extend these techniques to significantly larger molecules, nanoparticles and biological systems. We are developing new sources for these large systems based on soft vaporisation techniques (aerodynamic lenses, laser desorption, acoustic desorption, …) to provide high molecular fluxes over long measurement times (> 12 h), as required in typical FEL based imaging experiments. Using novel characterisation tools, such as super-resolution particle localisation [2] and plasma-formation imaging, new injectors are studied in detail and optimised. Coupling to efficient cooling schemes (supersonic expansions, buffer-gas cells) will provide internally cold molecules for further manipulation and control using static or dynamic electric fields. These will include the separation of structural isomers using Stark separation [1], alignment and orientation using laser-based strong-field techniques [3], as well as spatial control of particles using shaped quasi-Bessel laser beams [4]. This will allow the guiding of cold and controlled nanoparticles into the focused FEL beam, increasing hit-rates significantly, a major step towards single-particle diffractive imaging with atomic resolution.



Gas-flow map out of a Gas-Dynamic Virtual Nozzle (GDVN) injector recorded using Plasma Imaging. Inset shows the plasma formed at the tip of the GDVN.

[1] Chang, Horke, Trippel, Küpper, *Int. Rev. Phys. Chem.* **in press**, (2015); doi: 10.1080/0144235X.2015.1077838; arXiv: 1505.05632
[2] Awel, Kirian, Eckerskorn, Wiedorn, Horke, Rode, Küpper, Chapman, **submitted** (2015)
[3] Trippel, Mullins, Müller, Kienitz, Długołecki, Küpper, *Mol. Phys.* **111**, 1738 (2013)
[4] Eckerskorn, Li, Kirian, Küpper, DePonte, Krolikowski, Lee, Chapman, Rode, *Opt. Expr.* **21**, 30492 (2013)