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Speckle contrast from the split-and-delay unit with seeded X-ray pulses of the MID instrument at European XFEL

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The split-and-delay unit (SDL) at the MID (Materials Imaging and Dynamics) instrument of the European XFEL enables the splitting of a single FEL pulse into two fractions and delay one fraction in the range of femtoseconds to 800 ps [1]. This allows the investigation of dynamic processes on a molecular level in a temporal window that is difficult to access experimentally [2]. Especially the study of small molecular liquids, such as water and aqueous solutions, will benefit from this opportunity because many temperature and concentration dependent dynamics take place on the picosecond timescale. A prime example is the intermediate scattering function of molecular water, which from molecular dynamics simulations is expected to show the formation of a two-step relaxation process that strongly depends on temperature. For room temperature, the second step is found in the time window around 1 ps [3] which is exactly centered in the accessible region of the SDL unit of MID. The feasibility of such type of experiments has been shown by a measurement on pure water with SACLA split-and-delay optics [4]. Here, we report on the speckle contrast extracted from the scattering patterns and pulse splitting characteristics with seeded beam operation, which allows a high throughput of the SDL unit and reduced beam-induced dynamics in the sample. We further discuss the first experimental results from probing water in a jet, highlighting the invaluable potential of the SDL unit in advancing our understanding of fundamental processes of ultrafast phenomena in molecular liquids like water and aqueous solutions.

[1] W. Lu et al., Rev. Sci. Instrum., 89, 6, 063121 (2018).
[2] F. Lehmkühler, et al. Appl. Sci., 11, 13, 6179 (2021).
[3] P. Gallo, et al., J. Chem. Phys., 139, 20, 204503 (2013).
[4] Y. Shinohara et al., Nat. Commun., 11, 6213 (2020).

I plan to submit also conference proceedings

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