ESRF	**Experiment title:** Nanoparticle melting and shock shells	**Experiment number**: SC 1541
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Report:

In SC1177 we have already observed a strong structural reaction of the water phase on the photoexcitation of suspended gold and silver nanoparticles, which was related to the heat flux and expansional reaction of the water nearby the particles. The evolution of density, pressure and temperature in the water phase where however unclear. Within this experiment we have focussed on the determination of the reaction as function of delay and laser power. In order to get a complete picture of the structural relaxations the powder scattering from the gold particles [1], the change in diffuse scattering of the water phase [2] and as well SAXS were recorded.

This allows a more complete understanding of the dynamics. First is has been clarified, that the heat transfer of the gold nanoparticles is regular for low laser powers (powers that raise the lattice temperature not all the way up to the melting point). It can be described by continuum heat transfer equations [1, 3]. Above a sharp threshold this heat transfer breaks down and cooling is delayed. At the same time the strong transients in diffuse scattering are observed, which indicate a considerable compression of the bulk water phase [2, 4, see fig. 1]. It could be shown, that at this threshold the water undergoes a phase transition and vapour bubbles around the nanoparticles are formed within the time resolution of the experiment. Heat transfer is reduced. The change in pressure in bulk water allows the derivation of the bubble sizes, which ar in the sub-micrometer range [2]. These bubbles finally collapse after dissipating the heat within nanoseconds (depending on gold particle sizes). The reaction of the diffuse scattering in fig. 2 reflects this behaviour and resembles a simple solution of the Rayleigh-Plesset equation, called inertia limited growth. We have modelled the transient signal change with a parabolic rate of volume change.

Finally in the SAXS region very prominent structural features appeared, which showed unambigously the low density region around the gold nanoparticles and the existence of a rather sharp boundary in between the vapour nd the adjacent water phase. Both observations support the existence of explosion bubbles around the particles, as the water temperature in contact to the particles can rise to near the critical temperature.

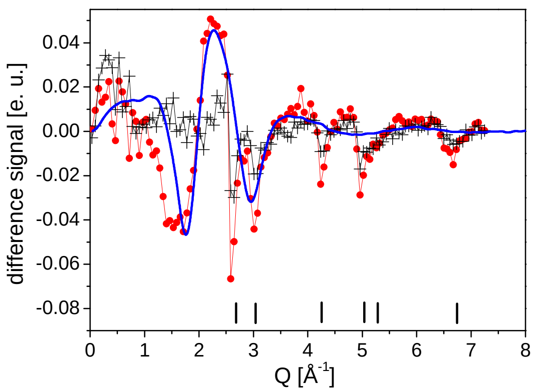

Fig. 1:*Difference intensity of the water scattering in between positive and negative (reference) delay in between laser and x-ray pulses. Crosses mark data below the threshold power for bubble formation, whereas the full dots mark data above the threshold.The shape of the signal is consistent with the change in density of bulk water due to compression (full line). The vertical bars are placed at the position of the gold fcc reflections, which reflect heating and melting of the gold particles.*

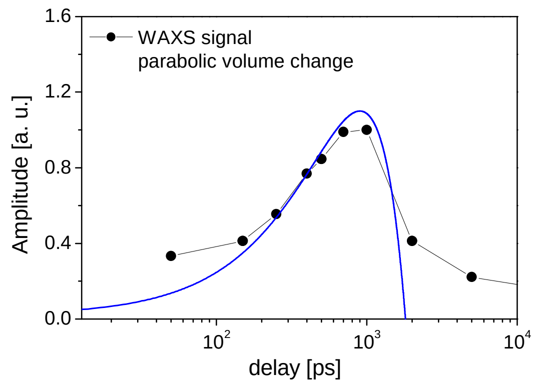

Fig. 2:*Amplitude of the diffuse scattering signal as a function of delay between laser and x-ray pulses at high power level (5x above the bubble threshold). The maximum in signal marks the maximum size of the excited vapour bubbles, which implode thereafter.*

While the phase change of water close to the nanoparticles could be precisely recorded, the limitation in beamtime did not allow to investigate as well the nonreversible changes of the particle morphology and the complete temporal evolution of the bubble dynamics, especially at the point of collapse. Both phenomena however would important for the understanding of the nonequilibrium thermodynamical conditions of these heavily driven systems.

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