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Report:

The dynamics of metallic glasses (MGs) delicately depends on the thermal treatment to which they get exposed. With x-ray photon correlation spectroscopy (XPCS), we studied the effect of the thermal history on the atomic motion of different MGs.
In particular we compared the dynamics of fast quenched metallic glasses (MGs), produced by melt spinning, with that of ultrastable metallic glasses (SMG), made by vapour deposition. The later are distinguished by their higher glass transition temperature and unique mechanical properties with respect to standard quenched MGs.
We studied two compositions: a binary and a ternary glass, namely $Cu_{50}Zr_{50}$ and $Cu_{65}Zr_{27.5}Al_{7.5}$, pre-treated with different thermal protocols. The dynamics was measured by means of wide angle x-ray photon correlation spectroscopy (WAXPCS) at the first sharp diffraction peak in the static profile which is about $q_0 \sim 2.5$ Å^{-1} while the structure was monitored by measuring the corresponding I(q) in the [1:4] Å^{-1} q range.
To investigate the influence of the previous thermal treatment in the ternary composition, we prepared different glasses by cooling the corresponding supercooled liquid with different rates and then we measured the dynamics by increasing the temperature, starting from 373 K and performing several isothermal steps up to 508 K ($T_{g,max}$ = 673 K).
Differently the binary samples have not been thermally pre-treated and have been measured by cycling through a temperature range between 476 K and 436 K.
To obtain information on density fluctuations from the captured intensity distribution by using two CCD cameras, we calculate the corresponding second order intensity correlation function $g^{(2)}(Q,t)$.

The CCDs were mounted at the same y-position but vertically shifted, corresponding to $-q_z$ and $+q_z$ in reciprocal space and collect photons with an exposure time of 3s, due to the low photon rate in coherent mode of the beam and the wide scattering angle, respectively. The obtained data were furthermore fit by the phenomenological Kohlrausch-Williams-Watts function to extract the relaxation time τ and the shape parameter β, according the following relation:

$$g^{(2)}(Q,t) = \frac{\langle I(Q,0)I(Q,t)\rangle}{\langle I(Q)\rangle^2} = 1 + A\exp\left[-2(t/\tau)^{\beta}\right]$$

Figure 1 (right) shows the temperature dependent relaxation dynamics of the binary SMG after cooling by steps of 20 K. Fig. 1 (left) shows, that the dynamics of this SMG is stationary during the captured isotherm, while it clearly changes with temperature. The comparison between the temporal and temperature evolution of the dynamics of the different measured glasses is still ongoing.

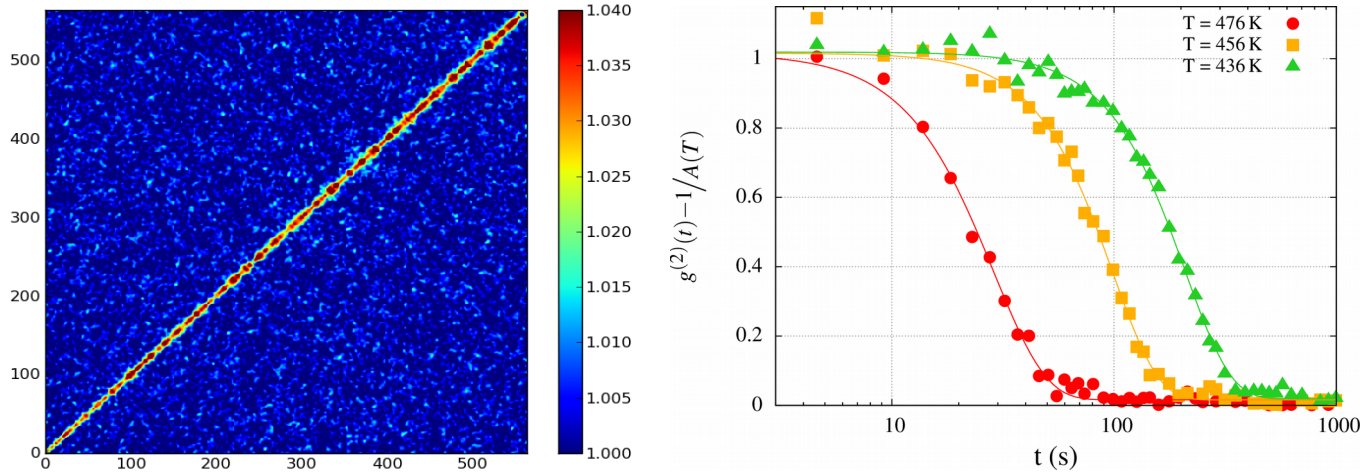

Figure 1: (Left) Two times correlation function, measured using WAXPCS for binary $Cu_{50}Zr_{50}$ metallic glass at q_0 = 2.54 $Å^{-1}$, fabricated by vapour deposition. The axis show the corresponding frame numbers of the intensity correlation of every captured image to their degree of correlation. (Right) Temperature dependence of the 2nd order correlation function, obtained by evaluating the intensity of the profile lines perpendicular to the main diagonal within the two times correlation function image.