Study of atomic motion in rubidium borate glasses

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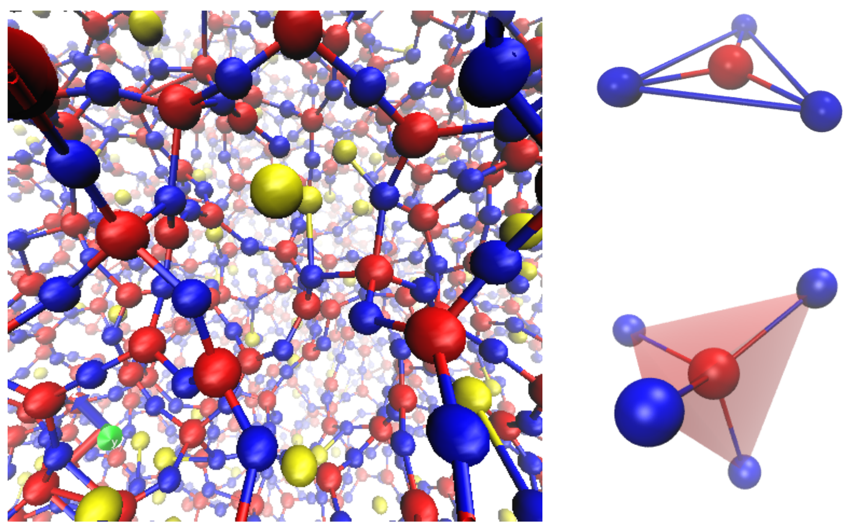
Introduction

Atomic Scale X-ray Photon Correlation Spectroscopy (**a**XPCS) uses coherent X-rays to probe the dynamics of materials on an atomic scale. It was applied to study atomic diffusion in crystals [1], but its application was recently extended to glasses as well [2]. Results of dynamics and Small-Angle X-ray Scattering (SAXS) studies on high- and low-alkali content rubidium borate glasses are presented here.

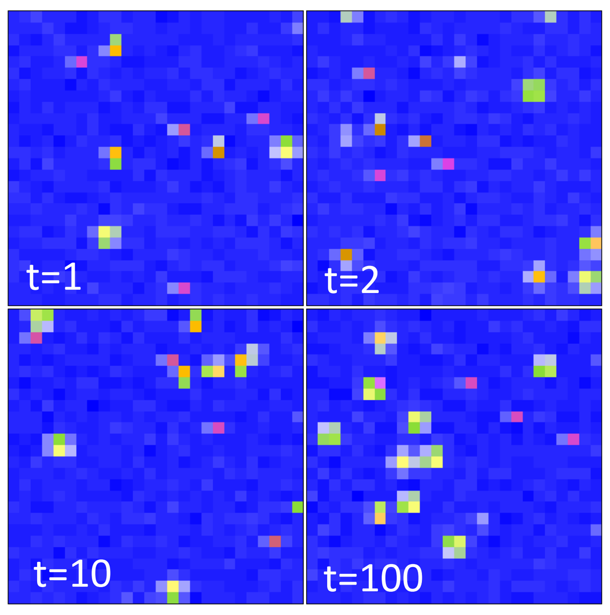
Theory

Real space structure: changes in time results in different scattering patterns



Space and time dependence described by the Van Hove Pair Correlation Function

Sequence of scattering patterns
⟶ Time correlation

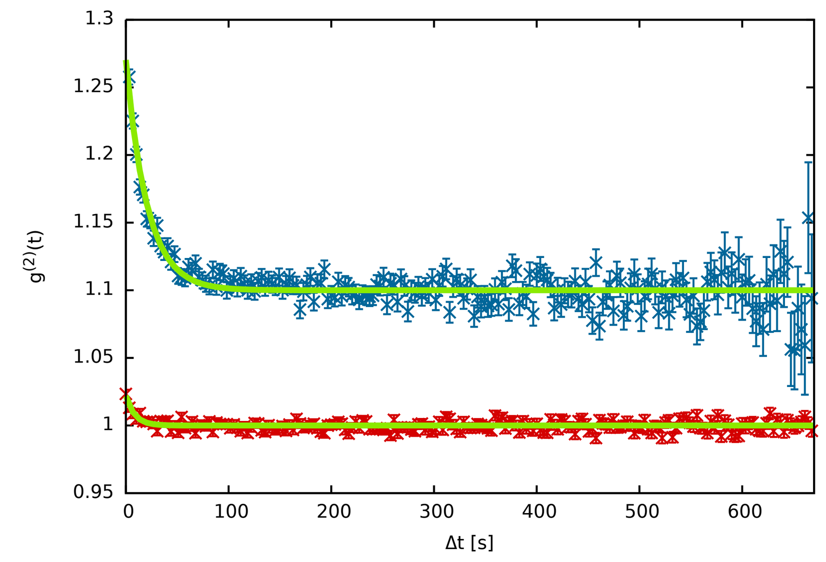


Intensity Auto Correlation Function (ACF)

$$g^{(2)}(\vec{q},\Delta t) := \frac{\langle I(\vec{q},t)I(\vec{q},t+\Delta t)\rangle}{\langle I(\vec{q},t)\rangle^2}$$

Functional form of the ACF:

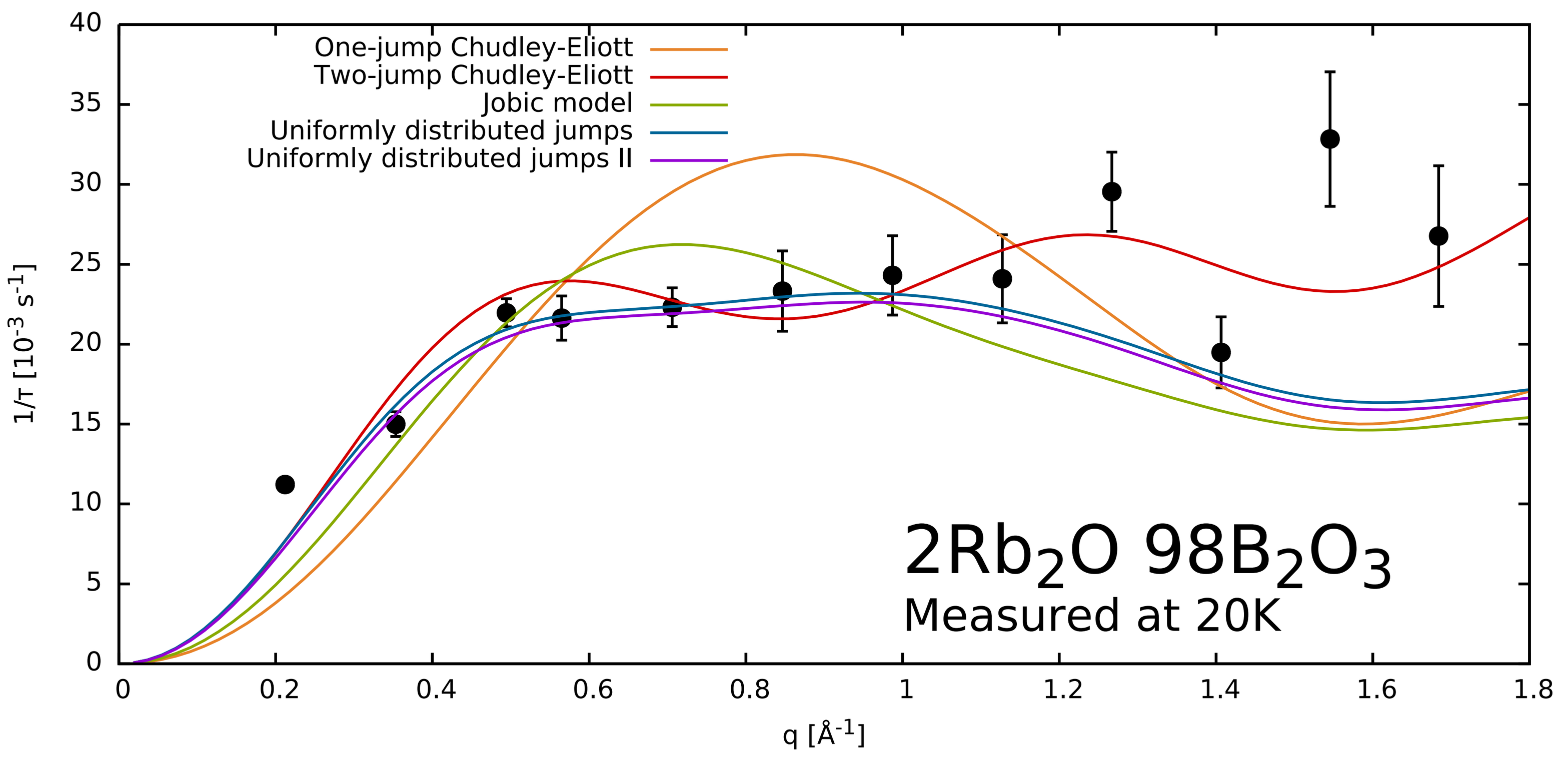
$$g^{(2)}(q) = 1 + \beta e^{-\left(\frac{2\Delta t}{\tau}\right)^{\alpha}}$$



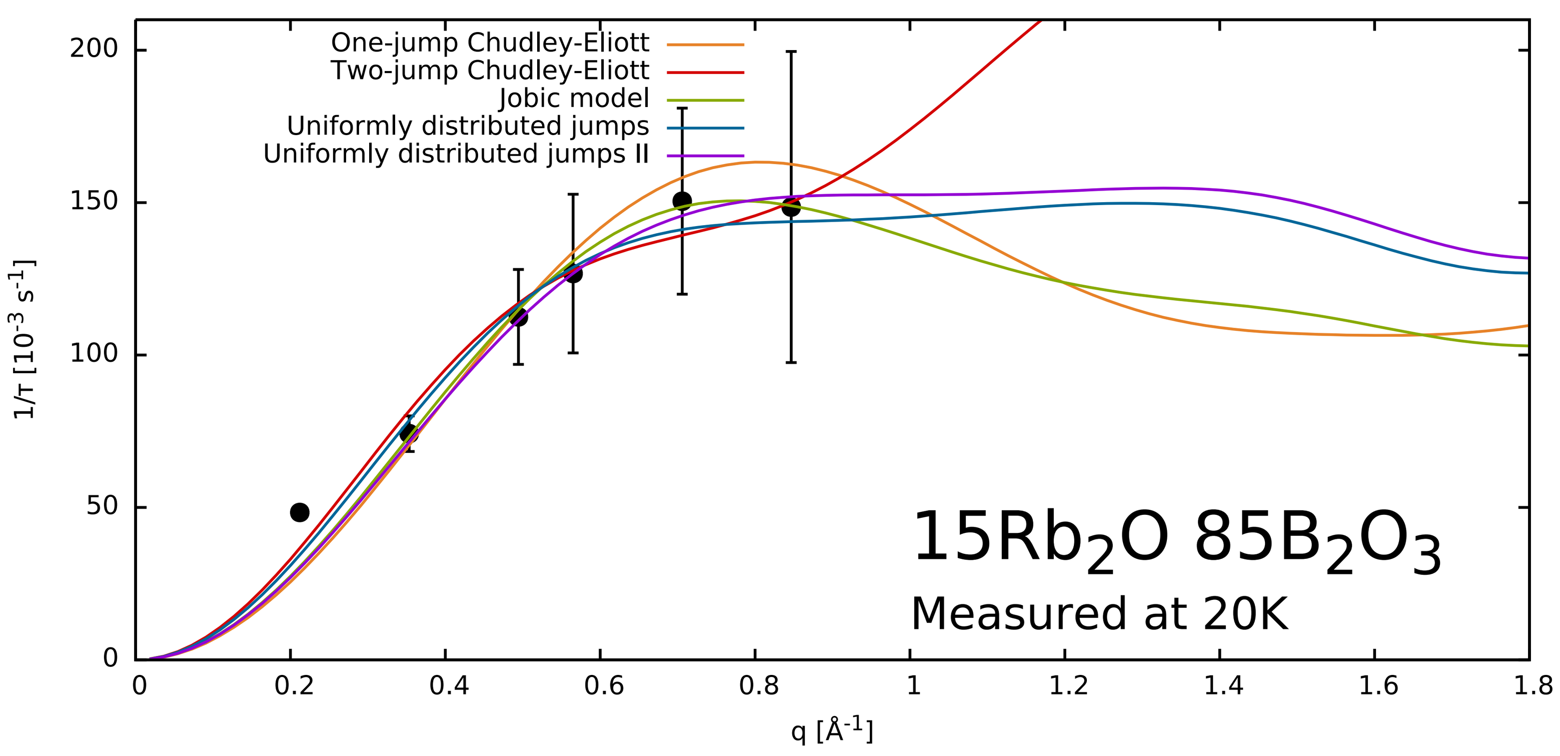
Normalization by the total structure factor

$$\tau_{coh}(\vec{q})^{-1} = \frac{\tau_{inc}(\vec{q})^{-1}}{S_{total}(q)}$$

Results: fit to jump models

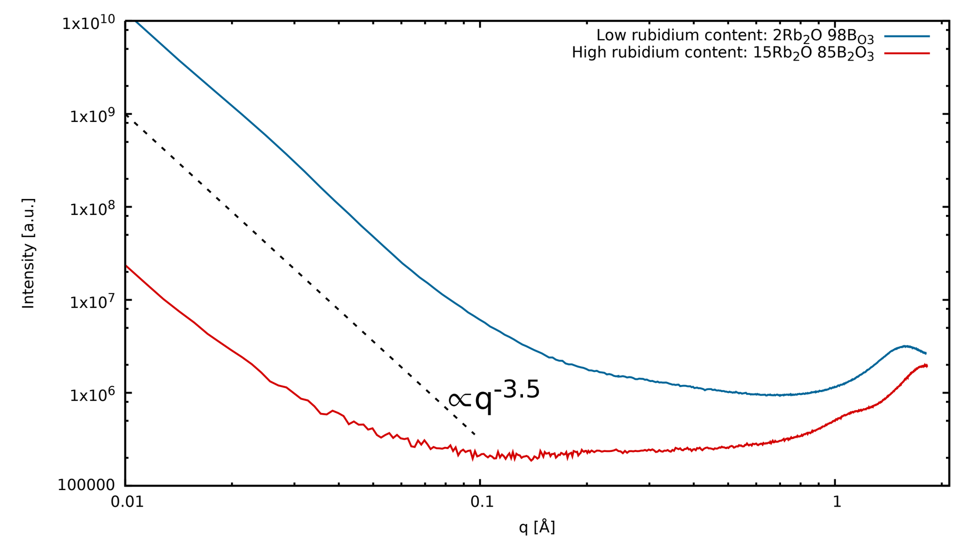


Best fit: Two-jump distances Chudley-Eliott Model with jump lengths $d_1 = 1.0$ Å and $d_2 = 8.5$ Å, with 3/4 of short-distance jumps



top: low alkali content glass, **bottom**: High alkali content glass. Several models can be fitted at small q-range. Fits are equally good in the hydrodynamic limit.

SAXS



SAXS intensities as a function of momentum transfer

Conclusion

- Diffusion in low rubidium content borate glasses best described by two-jump model
- Large difference in diffusivity between low and high alkali glass
- Diffusion at 20K still too fast to be measured in high alkali glass
- Inhomogenities are much larger in high alkali sample

[1] M. Leitner, B. Sepiol, L. M. Stadler, S. Pfau and G. Vogl, Nat. Mater, 8 (2009), 717.
[2] M. Ross, M. Stana, M. Leitner and B. Sepiol, New J. Phys. 16 (2014) 093042.

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