Detecting and quantifying local symmetries in disordered materials via speckle fluctuations

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Disordered matter –such as liquids and glasses – does not exhibit long range translational order and in turn is able to accommodate different local symmetries in the same system. Local structures have always been fascinating to scientists because they are held responsible for the undercooling of liquids and the existence of the glassy state. Moreover, non periodic materials have always attracted the attention of materials scientists, because they do carry, through their structural degrees of freedom, a unique potential to display smart functions.

However, the local microscopic structure of disordered structures has remained a challenge and a mystery. Conventional X-ray diffraction techniques fail to detect local structures because of their intrinsic spatial and temporal averaging mechanism. Our lack of knowledge on local order within disorder constrains the development of an understanding of the properties of liquids and glasses. Therefore, the question how those structures can be accessed experimentally has become one of the holy grails of condensed matter science.

The guiding principle to solve this problem is to avoid temporal and spatial averaging by using coherent X-rays [1]. The resulting speckle pattern of a liquid/glass reflects the exact spatial arrangement of all the particles in the beam and allows to test for local order. We show with the help of computer simulations how to construct proper speckle correlators and use statistical averages to detect and quantify local symmetries in disordered matter [2]. The newly developed techniques are employed to experimental data from colloidal glasses.

[1] P. Wochner, C. Gutt, T. Autenrieth, T. Demmer, V. Bugaev, A. Diaz Ortiz, A. Duri, F. Zontone, G. Grübel and H. Dosch, PNAS 106, 11511 (2009)
[2] C. Gutt et al. to be published