Dynamics of disordered materials

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Dynamics of Disordered Materials, Eds. D. Richter, A. J. Dianous, W. Petry, and J. Teixeira.-Proceedings of the ILL Workshop. Grenoble, France, September 26–28, 1988.-Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1989.-pp.323-(Springer Proceedings in Physics. V. 37.)

The dynamics of disordered materials was comparatively recently the object of new theoretical achievements which served as the basis for a large number of experimental papers. Thus for the interpretation of excess density of vibrational states observed in disordered materials or glasses collective excitations called fractons or low-lying modes in an anharmonic medium were proposed.

The book under review presents the materials of a workshop devoted to the dynamics of disordered materials which took place in September 1988 in Grenoble, and contains 10 review papers and approximately 40 articles. The aim of the workshop was to provide a platform for discussion between theoreticians and experimentalists whose interests lie in the aforementioned field.

The dynamics of materials in the course of vitrification and in adjacent fields extends over a large range of the time scale, and one should utilize quite different experimental methodology for a comprehensive study of the these phenomena. At the workshop many papers were presented utilizing the techniques of NMR, light scattering and others. But the majority of reports were devoted to work carried out utilizing the technique of neutron scattering—time of flight, back-scattering, spin-echo, because they cover a large range of transferred energy and momentum in investigating the response function.

The volume includes five parts. The first part consisting of a single paper by Egelstaff is an introduction to neutron scattering and presents it as an instrument for the study of glasses.

The second part is devoted to the dynamics around the glass transition. The modern theory of pairing of modes which predicts the existence of singularities in the dynamics at the liquid-glass transition is examined. Near a singularity the motion of particles depends upon two critical timescales, and the correlation function is described by two scaling laws. As a result of this it is predicted that the neutron scattering cross section must exhibit in vitrification anomalies near a certain critical temperature T_c situated usually at 3–150 K above the temperature of the transition T_g. The most important features of these anomalies are discussed.

In the third part of the book low-frequency excitations are investigated. Low-temperature anomalies in crystals with defects and in glasses, apparently, have a common nature and are explained by additional low-frequency excitations, that exist in these systems. The physical nature of these excitations is as yet unclear. During the last several years some measure of progress appeared in the understanding of the origin of the additional low-frequency modes in amorphous bodies, particularly stimulated by neutron-scattering experiments. Buchenau's review presents an analysis of three fundamental groups of excitations which coexist together with sound waves at low frequencies, specifically: 1) two-level or tunnel states (at very low temperatures); 2) structure relaxations; 3) additional harmonic vibrations. The results of investigations of eigenvectors of vibrational and relaxational modes carried out by the method of coherent inelastic neutron scattering, are compared with model calculations. Possible mechanisms of these excitations are discussed. Also deserving particular attention is a number of papers examining structure relaxations in amorphous materials; low-frequency excitations in metastable alloys obtained by quenching at high pressure; description of low-frequency excitations, processes of relaxation and two-level systems observed in crystals containing implanted atoms. The method developed in the last paper and based on the existence of a distortion of the lattice by implanted atoms can be useful for a better understanding of the amorphous state.

The last two chapters include problems of spin and orientation glasses and the dynamics of fractals. Comparisons are made of experimental data with calculations utilizing fracton models for the description of the dispersion law, the density of states and the lifetime of excitations in systems with fractal structure.

On the whole the collection of articles reflects the present state of the science of the dynamics of disordered materials and will be useful to physicists, experimentalists and theoreticians, engaged in these problems.

Translated by G. M. Volkoff