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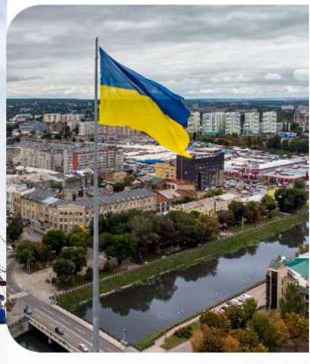
CONDENSED MATTER & LOW TEMPERATURE PHYSICS 2025

Abstracts book

2th - 6th June 2025
Kharkiv, Ukraine (Online)



B. Verkin ILTPE of NASU

V International Conference
Condensed Matter and Low Temperature Physics
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Book of abstracts

Kharkiv, B. Verkin ILTPE of NASU, 2025

UDK 538.9
H 88

Hurova D.E., Dolbin A.V., Shevchenko S.N. (editors) V International Conference “Condensed Matter and Low Temperature Physics” 2025. Book of abstracts. – Kharkiv: B. Verkin ILTPE of NASU, 2025. – 294 p.

ISBN 978-617-95455-9-7

This book collects 228 peer-reviewed reports presented at the V International Conference “Condensed Matter and Low Temperature Physics” 2025. These materials present the studies of modern aspects of condensed matter and low temperature physics including electronic properties of conducting and superconducting systems, magnetism and magnetic materials, optics, photonics and optical spectroscopy, quantum liquids and quantum crystals, cryocrystals, nanophysics and nanotechnologies, biophysics and physics of macromolecules, materials science, theory of condensed matter physics, technological peculiarities of the instrumentation for physical experiments, and related fields.

The book will be useful to undergraduate, postgraduate students, and researchers in the field of condensed matter physics.

Ця книга зібрала 228 доповідей, представлених на V Міжнародній конференції “Condensed Matter and Low Temperature Physics” 2025 року. Дані матеріали представляють дослідження у галузі сучасних аспектів фізики конденсованого середовища та низьких температур, у тому числі електронні властивості провідних та надпровідних систем, магнетизм, оптику, фотоніку та оптичну спектроскопію, квантові рідини та квантові кристали, кріокристали, нанофізику та нанотехнології, біофізику та фізику макромолекул, матеріалознавство, теорію фізики конденсованих середовищ, технологічні особливості обладнгання для фізичних експериментів та суміжні галузі.

Книга призначена для студентів, аспірантів та дослідників у галузі фізики конденсованого стану.

Recommended to publish by Scientific Council of B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine (protocol № 5, 16.04.2025)

Published by B. Verkin ILTPE of NASU
ISBN 978-617-95455-9-7

Classical and fractal models of chalcogenide glasses viscoelasticity

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This report presents experimental data on the viscoelastic behaviour of chalcogenide glasses in a sufficiently wide time (frequency) domain near the softening temperature and the models used to describe the mechanical relaxation processes.

Chalcogenide glasses have been extensively studied by various methods, however their long-term mechanical relaxation processes have not been investigated. We have therefore studied mechanical stress relaxation and creep on a torsion pendulum observing the time dependence of the torque in response to a step deformation or strain behavior under constant stress.

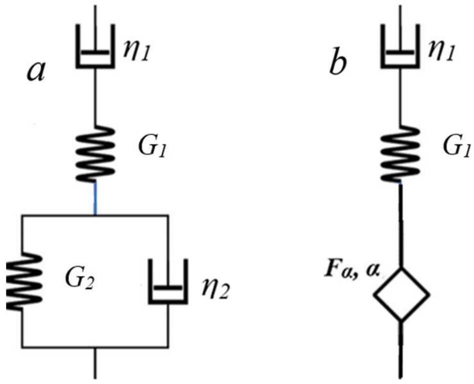

Fig. 1. Classical Burgers (*a*) and partially fractal (*b*) viscoelastic models.

As expected, an increase in temperature accelerates the relaxation processes, while the initial value of the mechanical stress σ, needed to achieve the constant strain, decreases with increasing temperature. Even at temperatures far from the glass softening temperature T_g, the strain ε does not disappear after removal of the mechanical load and relaxation for $(6\text{-}9)\cdot 10^3$ sec clearly indicates the presence of residual plastic deformation in the studied glasses. Taking the fact into consideration, we firstly considered the four-element Burgers model (Fig. 1 *a*), which consists of Maxwell and Kelvin bodies connected in series. The temperature dependence of these model parameters η_1, G_1 and η_2, G_2 were determined using experimental data on the relaxation of mechanical stress with time. For example, for As-Se glass with $T_g \approx 435$K, in the range of 370 – 430 K, G_2 decreases drastically from 150 GPa by more than a hundred times, while G_1 changes only from 6.0 GPa to 3.5 GPa.

Classical rheological models represent a simple combination of Hooke's and Newton's bodies, resulting in exponential stress and strain time dependencies. However, a vast of materials with complex microstructures, such as glasses, are characterized by a power-law dependence of their creep and stress with time. The power-law behaviour can be explained by generalizing the classical models by introducing a fractional derivative of different orders, which leads to the creation of fractal viscoelastic models. In order to reflect the diversity of viscoelastic behavior, it is advisable to use a combination of classical and fractal models; in particular, we proposed to replace the Kelvin-Voigt element by a fractal element in the Burgers model. In this way, purely elastic and plastic properties are reproduced, and the fractal element provides a power law for the behaviour of the mechanical parameters. The constitutive equation for this model is

$$\sigma + \frac{F_\alpha}{\eta}\frac{d^{\alpha-1}\sigma}{dt^{\alpha-1}} + \frac{F_\alpha}{G}\frac{d^\alpha \sigma}{dt^\alpha} = F_\alpha \frac{d^\alpha \varepsilon}{dt^\alpha}$$

, and its solution is as follows:

$$\varepsilon(t) = \sigma_0\left(\frac{1}{G} + \frac{t}{\eta} + \frac{t^\alpha}{F_\alpha \Gamma(1+\alpha)}\right).$$

Even this partially fractal model gives a better correlation between experimental and calculated data than the classical one. The parameter α of the fractal model varies within a small range: $0.25 \le \alpha \le 0.20$, while F_α decreases sharply, as expected, when the glass softening point is approached. It should also be noted that the introduction of fractality leads to an increase in the parameter η_1 of 20-25% with an unchanged value of G_1 in comparison with the classical model. It can be assumed that the physical meaning of the fractional derivative order in the description of viscoelasticity is determined by the fractal dimension of the relaxation times set.

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Kharkiv, B. Verkin ILTPE of NASU, 2025

Електронне видання, ум. друк. арк. 5.2.
Свідоцтво про внесення суб’єкта видавничої справи
до Державного реєстру видавців, виготівників
і розповсюджувачів видавничої продукції
від 07.06.2002 р., серія ДК № 941.
Видавництво ФТІНТ ім. Б. І. Вєркіна НАН України
просп. Науки, 47, Харків, 61103, Україна
https://www.ilt.kharkiv.ua