Generalized Fluctuation-Dissipation and the Magnetic Phases of Solid Oxygen

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Introduction

Measurements of the hysteresis for the temperature dependence of the electric susceptibility in the vicinity of the transition to the magnetic phases of solid oxygen have been used to test the predictions of simple replica symmetry breaking at a glass transition.

Experimental

A specially designed low temperature capacitance bridge was used for high sensitivity measurements of the dielectric susceptibility of solid oxygen in the vicinity of the transitions to the frustrated helical magnetic state (β-phase) and the collinear anti-ferromagnetic (α–phase).

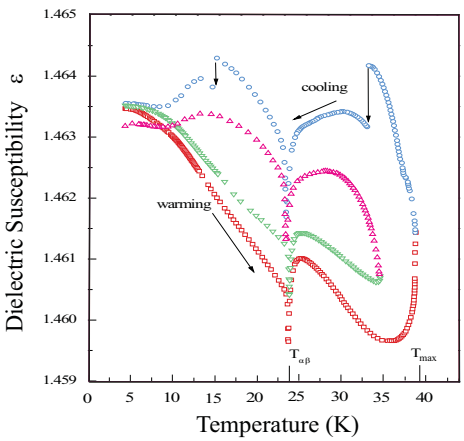

Figure 1. Thermal cycles through the transitions to the α- and β– phases of solid oxygen. The area of the hysteresis depends on the thermal history.

Results and Discussion

The characteristic aging and thermal histories of glass systems have been described as universal for simply frustrated systems [1] that are characterized by replica symmetry breaking [2]. The systems exhibit memory effects for the local order parameters and these memory effects can be considered in terms of generalized fluctuation dissipation theorems (GFDT). Recent NMR studies of thermal hysteresis effects observed for the orientational glass states of solid N_2-Ar mixtures[3] were shown to be consistent with GFDT and we sought a more stringent test by studying the frustrated magnetic phases of solid O_2.

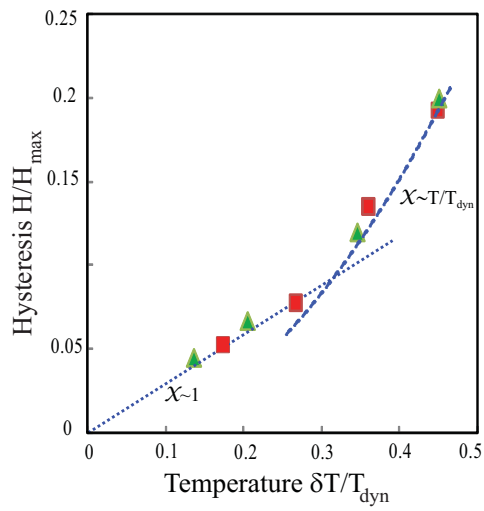

Figure 2. Comparison of the temperature dependence of the hysteresis loops shown in Fig. 1 for solid O_2 (red squares) and N_2 (green triangles) .

Conclusions

The thermal hysteresis effects observed for two different systems, solid O_2 and solid N_2, can be scaled to a universal curve (Fig. 2) using a generalized fluctuation dissipation theorem and scaling in terms of reasonable sales for the dynamical temperature in each system. This result is expected for these systems for which the nature of the frustration is very similar and for which simple replica symmetry breaking is expected.

References

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[3] Hamida, J.A.; Sullivan, N.S.; and Evans M.D., Phys. Rev. Lett. **71**, 173 (1993).