Photothermal and photoacoustic exploration of relaxation in supercooled liquids

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Background – Supercooled liquids exhibit the interesting property that a part of their dynamic response slows down over a large number of decades by cooling them down over some tens of degrees, with response times in the picosecond range at room temperature or higher till hours and even centuries at cryogenic temperatures, when a glass is formed. In view of applications, attention is typically given to their mechanical (translational and shear) and dielectric (rotational) response, which reflect the positional flexibility of atoms or molecules. Given the need for probing the response in a wide range of timescales, the large bandwidth provided by photoacoustic and photothermal (PAPT) techniques makes these very suitable for investigating glassy dynamics. In addition, the employed optical excitation mechanism gives experimental access not only to the mechanical response but also to the dynamics of the light to heat, heat to temperature change and heat to volume change or thermal expansion response, where the latter two can be characterized by a time/frequency dependent heat capacity and thermal expansion coefficient respectively.

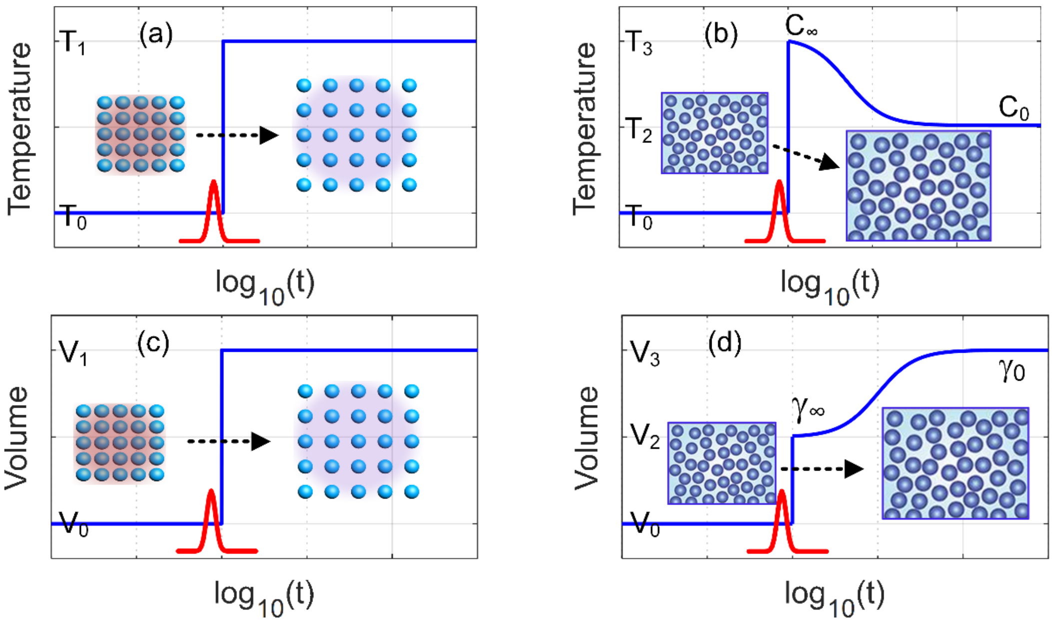

Fig. 1. Temperature variation (top) and volume variation (bottom) after transient photothermal heating to non-relaxing (left) and relaxing (right) system in adiabatic/isobaric conditions.

Methods – During the past years, the use of different PAPT approaches to extract information on the relaxation of the thermomechanical response has been explored, ranging from the photopyroelectric technique [1-2] to impulsive stimulated scattering [3-8], thermal lens detection [9] to fluorescence thermometry [10-11].

Results – In this contribution, a review is given of the methodology of the PAPT approaches that have been used in the past years and of the most recent advances. A new approach to model the combined phenomenology of photothermally induced temperature and volume changes in relaxing materials is presented. The contribution of the resulting findings to advances in the scientific field of soft matter physics is highlighted and perspectives are given for possible further steps to take.

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