Phonons in Charged Colloidal Crystals

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This talk deals with the particle dynamics in colloidal crystals made up of sub-micron sized charged particles dispersed in a deionized polar medium. The screened Coulomb repulsive interaction between charged colloidal spheres is responsible for the long-range translational order in colloidal suspensions. Since the concept of dynamical lattice is fundamental to the thermodynamic behavior of a crystal and colloidal crystals have close similarity with real crystals, it is of considerable interest to know the response of colloidal crystals to perturbations of a given wavelength, *i.e.,* phonon dispersion curves. For low particle volume fractions, colloidal crystals exhibit BCC ordering [1]. The theory of hydrodynamic interactions for colloidal crystals predicts that all the acoustic modes are over-damped except the transverse modes, which are predicted to be propagative in long-wavelength limit [2]. Dynamic light scattering (DLS) is the appropriate technique to measure the phonon dispersion in dilute colloidal crystals. Phonon dispersion curves of thin (thickness ~30-130μm) colloidal crystals have been measured using DLS [2,3]. The use of thin colloidal crystals, to prevent multiple scattering of light, prevented in observing the transition of overdamped transverse modes turning propagative in the long-wavelength limit.

Recently we have circumvented these limitations by closely matching the refractive index of particle with that of the medium, and by growing millimeter-sized colloidal crystals of silica (Si) particles dispersed in Ethylene glycol-water mixture (EG) by careful deionization and slow sedimentation[4,5]. We were successful in measuring phonon dispersion curves in large size (~3mm) charged colloidal crystals of Si/EG system using DLS[5]. At variance with the reports of phonon dispersion measurements on thin colloidal crystals our observations on millimeter-sized crystals showed unambiguous evidence for overdamped transverse modes turning propagative in the range of small wave numbers in qualitative agreement with the theory of hydrodynamic interactions in charged colloidal crystals[5]. The role of interparticle interactions, anharmonicity and disorder on phonon dispersion of charged colloidal crystals will also be discussed.

References

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