Investigation of Scattering Effects in Colloidal Systems

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Abstract

When the particles in a colloid come close to each other, multiple scattering in ultrasonic beams is no longer negligible and crowded particle effects emerge. The presence of each particle affects the scattering of all others, leading to coupling effects. We investigate the interaction of a range of sizes of particles, arranged periodically or randomly (in medium to high ultrasonic frequency fields), to understand their coupling and physical properties.

In order to determine the movement of particles in an ultrasonic field an investigation of small numbers of particles is also initially undertaken in order to firstly determine the extent of the displacement (and the function of particle position with respect to the origin of the ultrasonic beam) and secondly to understand coupled particle effects. One silica particle in water demonstrates the displacement in the field. Two particles are then used to show the range of interaction before examining chains and clusters. Other interactive energies, due to Coulomb repulsion are excluded from the analysis to completely focus on the wave motion and determine its influence on the particles (with neutral charge). It is expected that as the concentration of particles increases, the influence of shear-waves effects on an attenuation will become large [1].

Reference

1. D. M. Forrester et al, Experimental verification of nanofluid shear-wave reconversion in ultrasonic fields, Nanoscale, 8, 5497-5506 (2016)

Figures used in the abstract

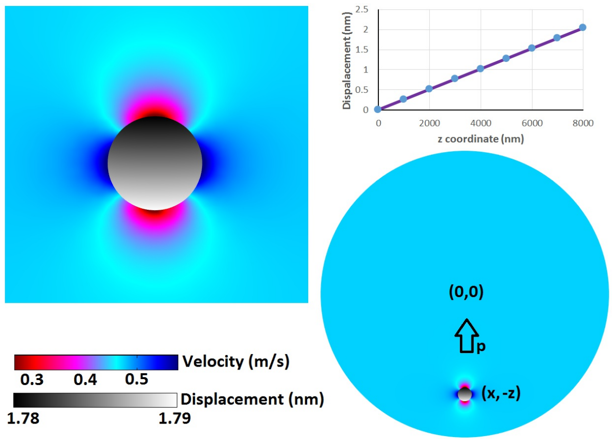

Figure 1: A spherical silica particle in a 1MHz ultrasonic plane wave with absolute pressure p0=1Mpa . The diameter of the particle is 1 micrometre and the coordinate system is referenced against the origin of a spherical domain of 20 micrometre diameter. The origin of the ultrasonic field is at z=-10 micrometres and the particle displacement is measured at various positions within the spherical domain. In the top right the displacement as a function of z is shown.

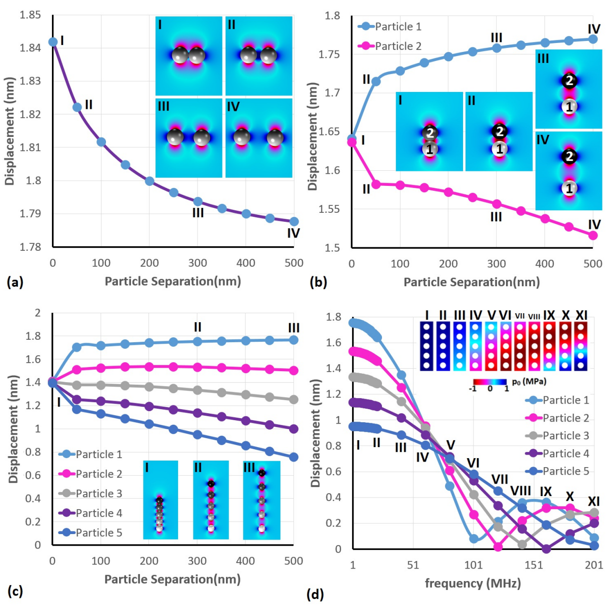

Figure 2: Two particle displacement with (a) Particles separated in the x-direction at z=7 micrometres. Initially the particle touch. The single particle average displacement is 1.785 nm and as the particles move apart the displacement tends to this value. (b) The particles start in contact and particle “2’s” position is changed. In the plane wave with frequency 1 MHZ particles at different z-direction coordinates experience different displacements, unlike the in-plane case of (a). (c) Five particles in aligned in the z-direction. (d) Particle displacement for five particles each separated by 300 nm at different frequencies.

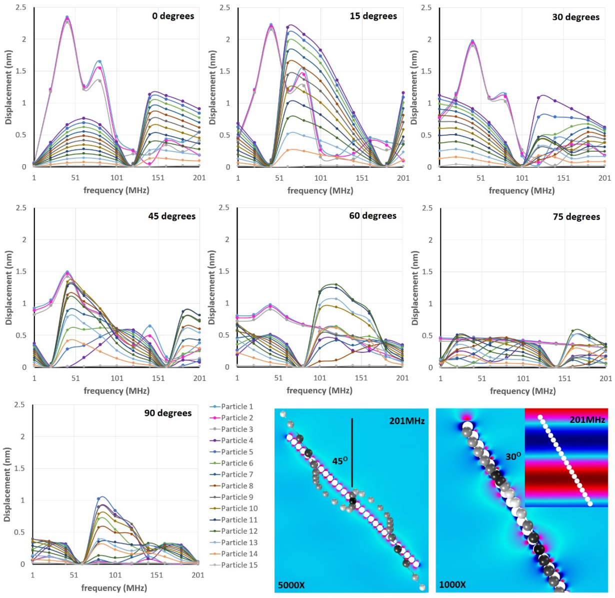

Figure 3: The displacement of twenty-nine touching particles at different angles and frequencies. In each plot the displacements of the bottom fifteen particles of the chain are shown.