Radiation force of acoustical waves: Practical examples and counter-intuitive phenomena

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“Usually big words signify very small specialties” [R.P. Feynman (1965) -- Speech on Quantum Electrodynamics]. Nonetheless, the acoustic radiation force is becoming a big word that signifies a very big subject, as demonstrated by the wealth of theoretical investigations and emerging applications in biomedical elasticity imaging and tissue characterization, “tractor” beams, acoustical tweezers, and the assembly of nano-composite metamaterials to name a few examples.

During this talk, practical medical imaging applications using radiation force vibro-acoustography will be illustrated. Moreover, surprises and counter-intuitive effects in particle manipulation will be presented and discussed. Namely, i) the ability of particle manipulation and transport will be demonstrated with examples using conventional sources and other complex-shaped wavefronts. Computations demonstrate the existence of both “repulsor” and “tractor” behaviors for which the axial force can be oriented along the direction of wave propagation (repulsor effect) or opposite to it (tractor effect). ii) Another phenomenon intrinsically connected with radiation force is related to the emergence of a negative spin radiation torque on an absorbing sphere, meaning that particle rotation can occur in opposite handedness of the incident beam. Finally, other examples demonstrate the manipulation (in the bulk) of diamond, copper and iron nano-particle clusters in diluted epoxy that solidify so as to form a stable polymer nanocomposite metamaterial structure. Various patterns (planar, columnar, circular) are achieved and experimental results show the successful synthesis of 3D structures. Furthermore, x-ray micro-computed tomography is used as a tool to characterize the stable structures.

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Short Bio

Farid G. Mitri is currently a senior scientist and subject matter expert (SME) with Chevron's Area 52 Technology - ETC, Santa Fe, NM. He aims to develop and design improved technologies and methods, devices/tools, data processing, quality control and modeling to support and complement ongoing and future research and development projects in oilfield applications. Farid held an Associate Professorship in Biomedical Engineering at the Mayo Clinic, Rochester, MN, United States, and a Director's Fellowship from the Los Alamos National Laboratory (LANL), Los Alamos, NM, United States. He is currently an Associate Editor of the IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency
Control (UFFC), a Program Committee Member of the UFFC Society, a Senior Member of the IEEE and an advisory committee member for the Laser-light and Interactions with Particles (LIP). Farid received his Ph.D. in biomedical engineering from the University Claude Bernard Lyon 1, Lyon, France, in 2004. His research has focused on the development of novel tools and applications in physical acoustics, physical optics, acoustic/electromagnetic scattering, biomedical ultrasound imaging and materials research, spanning ultrasound characterization methods, medical and nondestructive imaging, particle manipulation, and numerical modeling to name a few areas. Farid has published 185 peer-reviewed articles and hold three US patents. He is the recipient of the 2005 Lyon City Young Investigator Award, the 2007 Edward C. Kendall (Nobel Prize for Physiology and Medicine, 1950) award from the Mayo Clinic, the 2010 Director’s Fellowship from LANL, and the presidential medal of honor of the Lebanese National Order of the Cedar.