BRIEF DESCRIPTION

[0009] The present disclosure relates, in various embodiments, to acoustophoretic devices and methods of separating a second fluid or a particulate from a host fluid. Briefly, a superposition of multi-dimensional acoustic standing waves is used to continuously trap the second fluid or particulate, which then agglomerates, aggregates, clumps, or coalesces together, and subsequently rises or settles out of the host fluid due to buoyancy or gravity forces, and exits the acoustic chamber.

[0010] *Method disclosed herein for separating a second fluid or a particulate from a host* fluid comprise flowing a mixture of the host fluid and the second fluid or particulate through an acoustophoretic device. The acoustophoretic device comprises an acoustic chamber having at least one inlet and at least one outlet; at least one ultrasonic transducer located on a wall of the acoustic chamber, the at least one ultrasonic transducer including a piezoelectric material driven by a voltage signal to create a superposition of multi-dimensional acoustic standing waves in the acoustic chamber; and a reflector located on a wall on the opposite side of the acoustic chamber from the at least one ultrasonic transducer. The method further comprises sending a voltage signal to drive the at least one ultrasonic transducer in a displacement profile that is a superposition of a combination of different modes (such as planar, fundamental, and/or higher order mode shapes) that are the same order of magnitude to create the multi-dimensional acoustic standing wave in the acoustic chamber such that the second fluid or particulate is continuously trapped in the standing wave, and then agglomerates, aggregates, clumps, or coalesces together, and subsequently rises or settles out of the host fluid due to buoyancy or gravity forces, and exits the acoustic chamber.

[0010a] In one aspect, there is provided a method for separating a second fluid or a particulate from a host fluid, comprising:

flowing a mixture of the host fluid and the second fluid or particulate through an acoustophoretic device, the acoustophoretic device comprising:

an acoustic chamber having at least one inlet and at least one outlet;

at least one ultrasonic transducer located on a wall of the acoustic chamber, the at least one ultrasonic transducer including a piezoelectric material driven by a voltage signal to create a multi-dimensional acoustic standing wave in the acoustic chamber; and

a reflector located on a wall on the opposite side of the acoustic chamber from the at least one ultrasonic transducer; and

sending a voltage signal to drive the at least one ultrasonic transducer in a displacement profile that is a superposition of a combination of different modes that are the same order of magnitude to create the multi-dimensional acoustic standing wave in the acoustic chamber such that the second fluid or particulate is continuously trapped in the standing wave, and then agglomerates, aggregates, clumps, or coalesces together, and subsequently rises or settles out of the host fluid due to buoyancy or gravity forces, and exits the acoustic chamber.

[0011] Mode (1, 1) is known as the fundamental mode. The fundamental and higher order mode shapes may have peaks within 0.005 MegaHertz of each other. The higher order mode shapes may include modes (1, 3); (1, 5); (3, 3); (3, 5); and (5, 5). In certain embodiments, the higher order modes may include modes up to (25, 25) and higher.

[0012] A frequency of excitation of the piezoelectric material can be changed or dithered over a small interval, exciting the piezoelectric material in multiple higher order modes, and then cycling the frequency back through lower modes of the piezoelectric material , thereby allowing for various multi-dimensional wave shapes, along with a