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Focused ultrasound beyond phase-arrays: acoustic holographic lenses enable transcranial focusing of arbitrary fields at the central nervous system

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Focused ultrasound is currently used in many emerging therapeutic applications for the non-invasive treatment of neurological disorders and pathologies inside the central nervous system. The accurate focusing ultrasound beams at the central nervous system is mainly limited due to the strong phase aberrations produced by refraction and attenuation of the skull. In this talk we will present 3D-printed acoustic holographic lenses for the generation of ultrasonic fields of complex spatial distribution inside the skull. Using holographic lenses, we experimentally, numerically and theoretically produce acoustic beams whose spatial distribution match the volume of target structures of the central nervous system. This include multiple-target foci, self-bending beams and focusing over arbitrary volumes. In this way, the focus of the corresponding holographic lens overlaps with the target volume in excellent agreement between theory in free-media, experiments and simulations including a skull phantom. Using the present method, ultrasonic beams can be focused not only at a single point, but overlapping one or various target structures simultaneously, e.g., left and right hippocampi, using low-cost 3D-printed acoustic holographic lens. These results open new paths to spread emerging biomedical ultrasound applications including blood-brain barrier opening or neuromodulation.

