Seeing (Ultra-)Sound Through Mechanoluminescence

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Mechanoluminescence (ML) is the process of light emission by a material after mechanical stimulation. Unlike destructive ML, where an electric discharge takes place after bonds are broken (common in about 50 % of all solids), non-destructive repeatable ML is possible in certain photoluminescent materials. These materials consist of a host compound doped with a few percentages of (typically lanthanide) impurities. When a phosphor contains so called ‘traps’, charge carriers can be trapped and stored for long periods of time before they are released and cause light emission. These traps can be emptied thermally (at room temperature, this is called afterglow) or by mechanical stimulation (stress). In the latter case, according to the *localized piezoelectrically induced detrapping model* a piezoelectric host crystal is required, exhibiting an electric field upon external stress which effectively reduces the trap depth[1].

In our research, ML phosphors are used to visualize the radiation field of a 3.3 MHz ultrasound transducer. It turns out that the pressure profile of a sound wave is well suited to produce the ML effect, coined “Acoustically induced Piezoluminescence” (APL). A glass substrate is coated with the phosphor powder and placed in the ultrasound pressure field. After charging the sample with ultraviolet radiation (thus filling the traps) and waiting for the afterglow to diminish, a cross section of the ultrasound radiation field can be observed as light emission from the sample. Repeating this process at several distances from the transducer and photographing the ML signal in transmission, a complete mapping of the radiation field is possible in a short amount of time[2] (see Figure 1). In this way, APL imaging provides a fast way to check the uniformity of an ultrasound transducer.

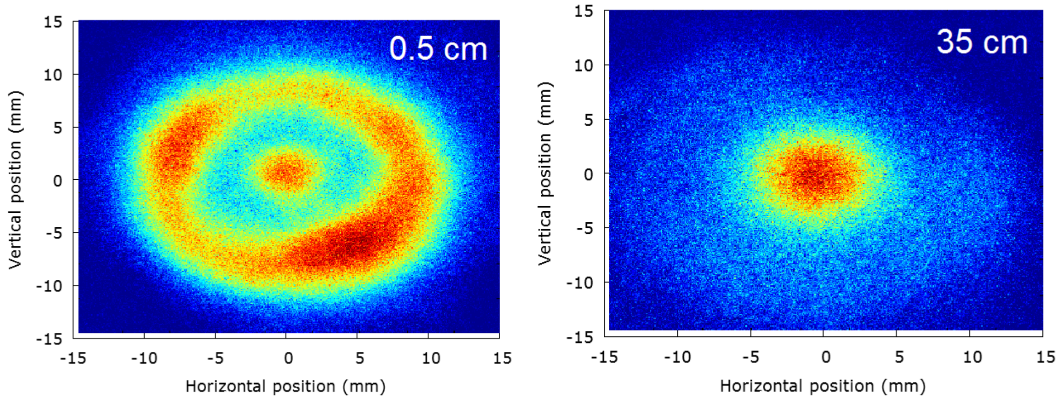

Figure 1: Cross sections of the APL intensity in an ultrasound radiation field at distances z=0.5 cm and z = 35 cm from the transducer.

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[2] M. Kersemans; P. F. Smet; N. Lammens; J. Degrieck and W. Van Paepegem. Fast Reconstruction of a Bounded Ultrasonic Beam using Acoustically induced Piezo-Luminescence. Appl. Phys. Lett. 107, 234102 (2015).