



Leonid Gavrilov



Pioneer Award

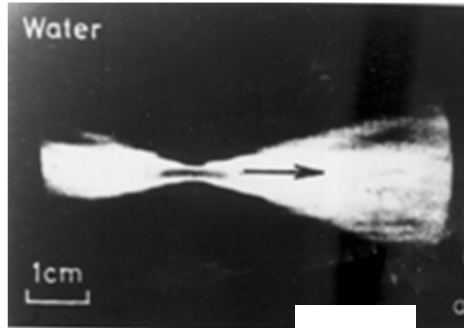


Major discoveries that are emerging into clinical applications right now

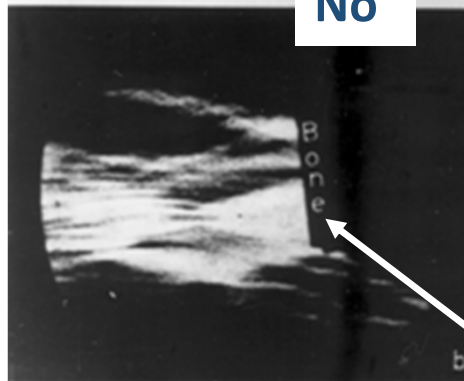
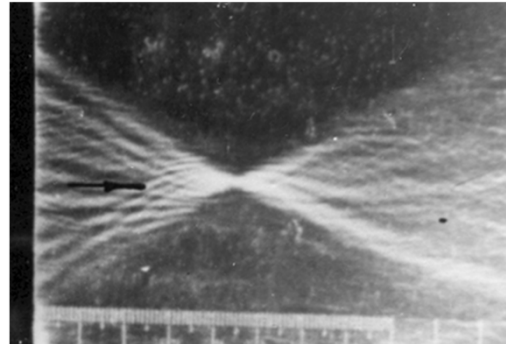
Feasibility of US focusing through the skull

Frequencies 0.5 and 1.0 MHz

Fresh bone, normal incidence



No



Skull bone

Prof. P.P. Lele,
Ultrasonics, 1967

Bulletin of Experimental Biology
and Medicine, 1971, 1973

Schlieren images confirmed that ultrasound
can penetrate through human skull

Patent USSR, 1970



HIFU lesioning through intact skull

Acoustics Institute, Central Designing Bureau and Brain Institute
of the USSR Academy of Medical Sciences

Animals, 1973

Tyurina S. I., ... Gavrilov L. R. Use of focused ultrasound for local destruction of brain structures without damage to the skull.
Bull. Exp. Biol. Med. 1973, 75, 5, 597-598.

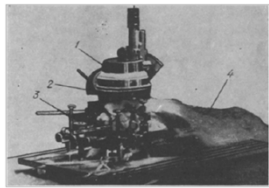


Fig. 1. The use of focused ultrasound in a stereotaxic apparatus: 1) generator; 2) rubber bag filled with distilled water; 3) stereotaxic apparatus; 4) rabbit.

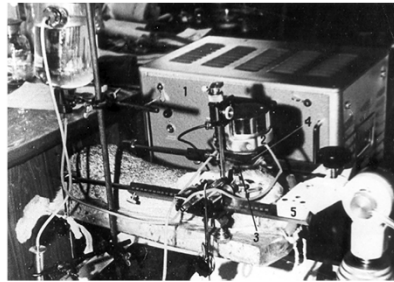
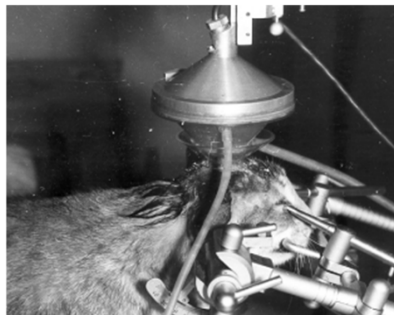


Fig. 2. Focus of destruction in hypothalamic region of a rabbit's brain (arrow), Nissl, 15x.

1 MHz, 1500 W/cm²
5 pulses x 1 s

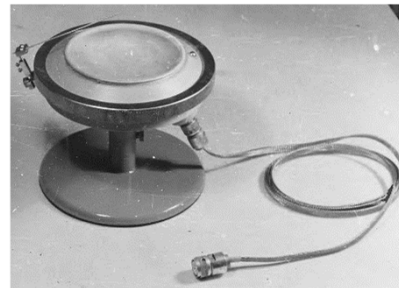


Human cadavers , 1977

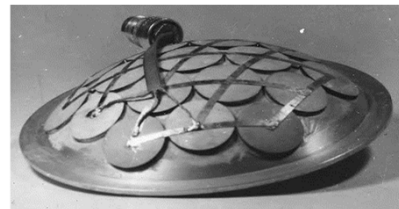
Korsakov A.S., Tyurina S.I., Gavrilov L.R., Brazovskaya F.A. Development of a method of local destruction in the depth of the brain by irradiation with focused ultrasound through intact hair, skin and skull / In the book: The Use of Ultrasound and New Types of Energy in Diagnostics, Therapy and Surgery. M. 1977. S. 108.

High-power mosaic transducer

Acoustics Institute

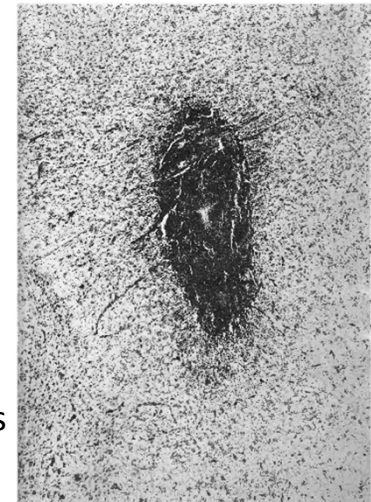


$f = 1 \text{ MHz}$
 $D = 160 \text{ mm}$
 $F = 106 \text{ mm}$
 $S = 250 \text{ cm}^2$
 $W = 0.6 - 1.5 \text{ kW}$



In situ

20 kW/cm² (!)
8 - 20 pulses 0.5-1 s
repetition 0.5 Hz



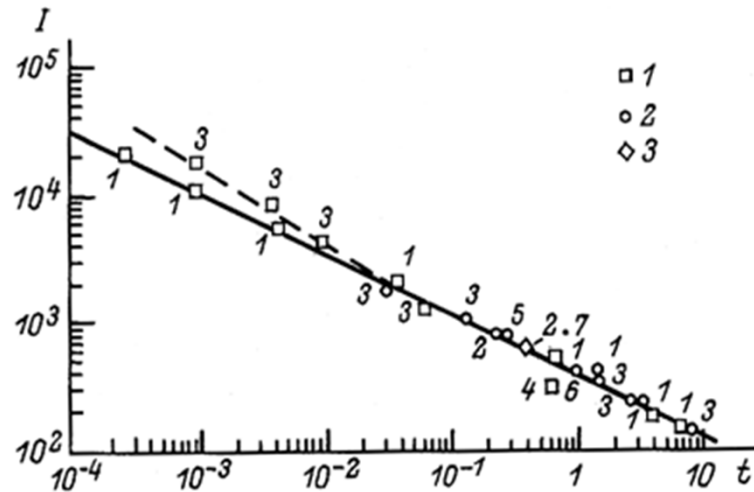
Classic work referred to as the first in this field: Fry F.J., Goss S.A. UMB 1980; 6: 33-38

Measurement of cavitation thresholds in animal brains *in vivo* (1973-1974)

Acoustics Institute and Institute of Brain of the USSR Academy of Medical Sciences

Measurements of cavitation thresholds
L.R.Gavrilov, Sov.Phys.Acoust. 1974

Threshold ultrasonic dosages for structural changes in mammalian brain. Fry F. *et al.* JASA, 1970



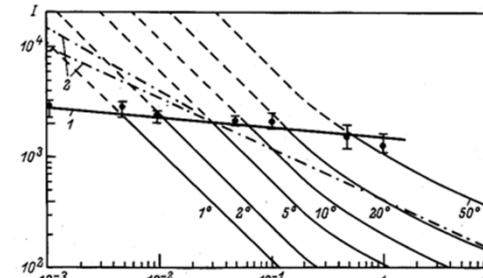
Physical mechanism of the lesion of biological tissues by focused ultrasound

L. R. Gavrilov

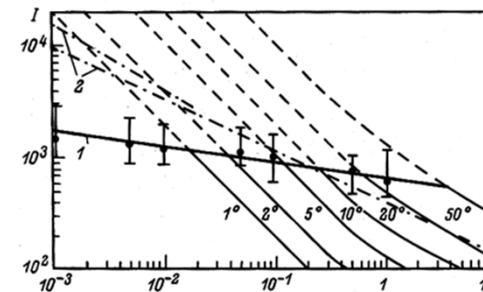
Acoustics Institute, Academy of Sciences of the USSR

(Submitted October 27, 1972)

Akust. Zh., 20, 27-32 (January-February 1974)



$f = 1.72$ MHz



$f = 0.94$ MHz

Stimulation of sensation effects by focused ultrasound

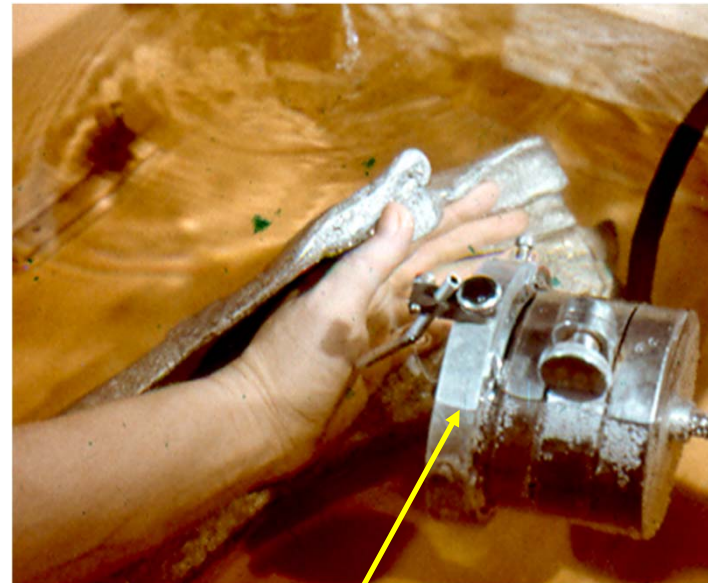
1972-1973 and further

Acoustics Institute and Institute of Evolutionary Physiology

Frequency from 0.5 to 3 MHz; single pulses from 0.5 to 100 ms;
intensity from units to hundreds of W/cm^2



3-D positioner



Focused transducer

It was shown that pulsed focused ultrasound can induce different somatic sensations (tactile, warmth, cold, pain) in humans

Proposed mechanism – acoustic radiation pressure

Stimulation of hearing effects by focused ultrasound

1972-1973 and further

Acoustics Institute and Institute of Evolutionary Physiology



It was shown that US modulated by sound signals (tone, speech, music) induce hearing sensations determined by the character of modulation.

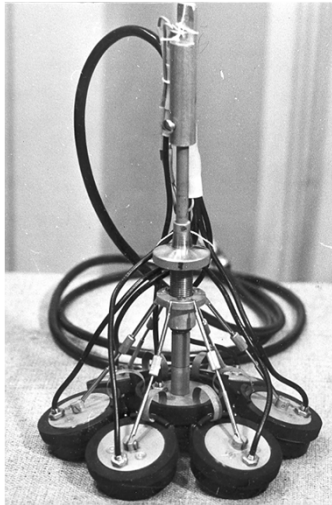
Thresholds of HIFU-induced sensations can be measured and used to diagnose neurological, skin and hearing diseases

Proposed mechanism – acoustic radiation pressure

Designing ultrasound generators and transducers

Acoustics Institute. 1970-1980

7-element system, $f = 1$ MHz
with varying focal length



Various depths in tissue



Portable generator 0.5-3 MHz 300W



Set of transducers



$f = 0.5 - 3$ MHz
 $D = 6-8$ cm, $F = 5-7$ cm

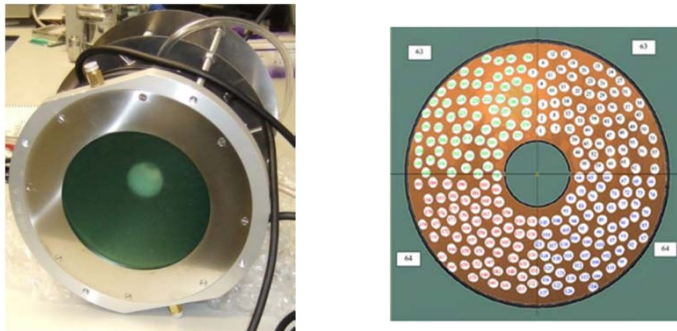
Rotary transducer
ablations of annular geometry
 $f = 1 - 2$ MHz



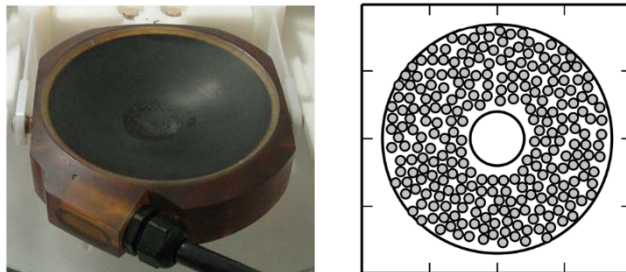
High-power multi-element 2D random phased arrays

Not only randomization is important, but the directivity of elements, $D \leq 5\lambda$

Imperial College (2009), 1 MHz, 256 elements
diameter 7 mm (4.7λ)



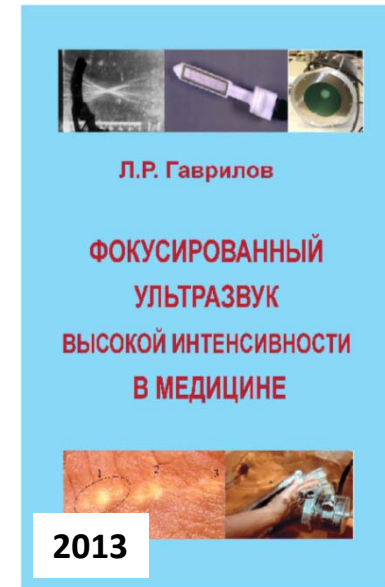
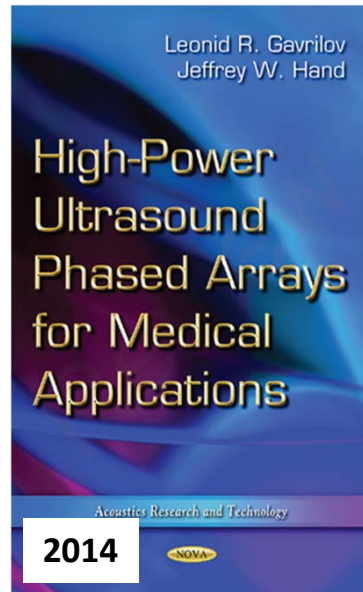
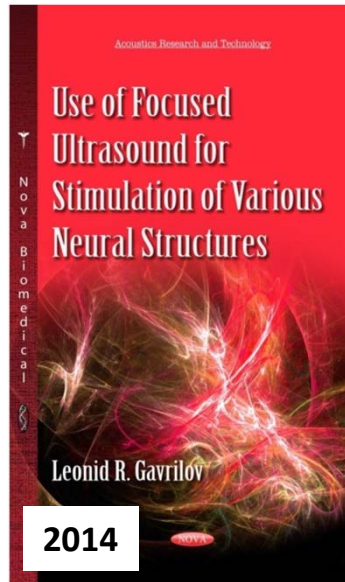
Universit'e Paris, 0.9 MHz, 200 elements
diameter 8 mm (4.8λ)



Sonalleve V1 MR-HIFU system (Philips/Profound)
1.2 MHz, 256 elements, diameter 6.6 mm (5.3λ)

Gavrilov L. R., Hand J. W. IEEE Trans. UFFC, 2000, 47, No 1, 125-139 - strong effect of randomization

Goss S.A. et al. IEEE Trans. UFFC, 1996 2.1 MHz, 108 elements diameter 8 mm (11.2λ) – weak effect



Congratulations to Leonid!

