4CF07-2007-020006

Abstract for an Invited Paper
for the 4CF07 Meeting of
the American Physical Society

Energy Concentrating Phenomena: From Sonoluminescence to Crystal Fusion

SETH PUTTERMAN, University of California, Los Angeles

Fluids and solids that are driven off equilibrium do not relax smoothly to equilibrium. Instead they display a wide range of energy focusing phenomena. In sonoluminescence (SL) a pulsating bubble concentrates the ambient acoustic energy density by 12 orders of magnitude to create picosecond flashes of broadband ultraviolet light. At the minimum bubble radius where the contents have been compressed to their van der Waals hard core the acceleration exceeds 10^{11}g and a Mega-Bar level shock wave is emitted into the surrounding fluid. For single bubbles driven at 30 kHz SL is nature's smallest blackbody. At 1 MHz the spectrum resembles Bremsstrahlung from a transparent plasma with a temperature $\sim$1 MK and a nanometer radius. Whether cavitating systems will reach energy densities that initiate thermonuclear fusion is an open question. Ferroelectric crystals, however, can be configured to create nuclear fusion in a palm-sized apparatus. When the temperature of a ferroelectric crystal [e.g. Lithium Tantalate] is slightly varied, electrons are expelled with energies that can exceed 100 keV. By configuring the crystal surface with a field ionization tip, pyroelectricity can be used to generate and accelerate ions to energies where nuclear fusion occurs. Hoped-for applications range from miniature x-ray devices to neutron cameras to ion thrusters. In seeking to improve these devices one faces the question: what physics processes limit the spontaneous polarization [and resulting internal field] that can be produced with a ferroelectric crystal? For $\sim$50 years Lithium Niobate has exhibited the highest ratio of spontaneous polarization to dielectric constant. Why haven't superior materials been discovered? Is there a fundamental limit set by the laws of physics?