Among various methods for the acceleration of dense matter and especially ion beams the mechanism called Laser-Induced Cavity Pressure Acceleration (LICPA) offers the possibility of obtaining the highest energetic efficiency [1,2]. The LICPA approach is based on the exploitation of the laser-induced thermal plasma pressure or the radiation pressure of laser radiation trapped in the cavity to accelerate a projectile along a guiding channel. It leads to a significant enhancement of hydrodynamic or electromagnetic forces driving the projectile in comparison to the standard laser acceleration schemes and to an increase in the projectile density due to collimating properties of the channel.

The aim of this contribution is to review recent experimental and theoretical works on LICPA with the emphasis on applications for acceleration of dense ion beams and heavy macroparticles. The main experimental part concerns the research performed at the kilojoule PALS laser facility in Prague (offering 0.3-ns laser pulses of intensity $\sim 10^{14} – 10^{16} \text{ W/cm}^2$) where the plasma accelerated and collimated in various (cylindrical, conical) LICPA configurations was investigated with the use of several diagnostics (interferometry, ion diagnostics, X-rays and neutron diagnostics, as well as measurements of the plasma-produced craters). It is shown that in this long-pulse hydrodynamic regime parameters of both ion beams and heavy macroparticles accelerated in the LICPA scheme are considerably higher compared to conventional acceleration schemes, with the energetic efficiency of acceleration higher by an order of magnitude.

Using particle-in-cell simulations it is demonstrated that the LICPA scheme is highly efficient also in the photon pressure regime and, in particular, may be used for production of high-energy ($\sim \text{GeV}$) ion beams of extreme intensities ($> 10^{20} \text{ W/cm}^2$) and current densities ($> 10^{12} \text{ A/cm}^2$) with the efficiency approaching tens of percents.