

# Equation of state studies of High Energy Density Matter using intense ion beams at the FAIR facility at Darmstadt

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High Energy Density (HED) physics is important as it involves numerous branches of basic and applied physics including astrophysics, planetary physics, inertial fusion, strongly coupled plasmas and many others. Experimental studies of the Equation of State (EOS) and transport properties of HED matter is an active research area for the past many decades. Traditional method of generating HED matter in the laboratory mainly involves shock compression of matter. With the development of highly energetic, strongly bunched, well focused intense ion beams, a new method has been proposed that induces HED states in matter by uniform and isochoric heating of solid targets.

A powerful heavy ion synchrotron, SIS100 is being constructed at the Facility for Antiprotons and Ion Research [FAIR] at Darmstadt, which will deliver intense ion beams of all stable ion species from protons up to uranium. For the HED physics studies, uranium beam is most desirable as it deposits the highest specific energy. The design beam parameters include an intensity of  $5 \times 10^{11}$  uranium ions per bunch with bunch length of 70 – 100 ns. The transverse intensity distribution in the focal spot is considered to be Gaussian with full width at half maximum (FWHM) of 1 – 2 mm. It is to be noted that during the early stages of operation, the beam intensity will be lower ( $10^{11}$  ions per bunch).

To assess the potential of the FAIR facility to generate HED matter in the laboratory, we have carried out extensive simulation studies of beam-matter heating employing a 2D hydrodynamic code BIG2 using the above parameter range. These simulations have shown that the FAIR uranium beam will deposit enough specific power in the target to generate all interesting HED states including that of an expanded hot liquid, two-phase liquid-gas state, gaseous state, critical parameters and strongly coupled plasma phase. Several metallic targets have been considered. An experimental scheme named HIHEX (Heavy Ion Heating and Expansion), has been proposed to measure the EOS properties of HED matter using this technique. Determination of the EOS requires simultaneous measurement of density, temperature and pressure. In the HIHEX experiments, temperature will be measured by using an optical pyrometer, the pressure will be measured using laser interferometry while the density will be measured using the x-ray shadowgraphic technique.