Studies of heavy ion-induced high-energy density states in matter at the GSI Darmstadt SIS-18 and future FAIR facility

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Abstract

This paper presents numerical simulation results of heating and compression of matter using intense beams of energetic heavy ions. In this study we consider different beam parameters that include those which are currently available at the heavy ion synchrotron, SIS18 at the Gesellschaft für Schwerionenforschung (GSI), Darmstadt and those which will be available in the near future as a result of the upgraded facility. In addition to this, we carried out detailed calculations considering parameters of high-intensity beam which will be generated at the GSI future Facility for Antiprotons and Ion Research (FAIR facility) that has been approved by the German Government. These simulations show that by using the above ion beam parameter range, it will be possible to carry out very useful studies on the thermophysical properties of high-energy density (HED) states in matter. This scheme would make it possible to investigate those regions of the phase diagram that are either very difficult to access or even are unaccessible using the traditional methods of shock waves. Moreover, employing a hollow ion beam which has an annular (ring shaped) focal spot, it would be possible to achieve a low entropy compression of a test material like hydrogen, which is enclosed in a cylindrical shell of a high-density material such as lead or gold. These experiments will enable one to study the interiors of giant planets, Jupiter and Saturn as well as to investigate the problem of hydrogen metallization.

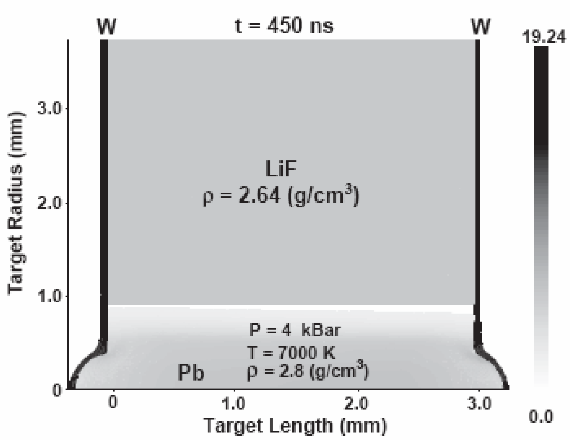

Fig. 7. Same as in Fig. 6, but at $t = 450$ ns.

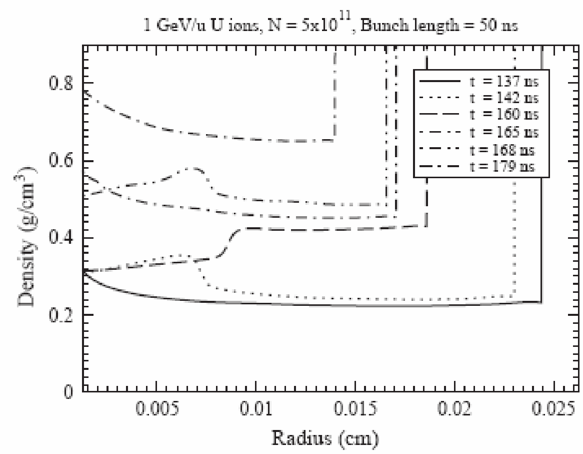

Fig. 8. Hydrogen density vs. radius at $L = 2.5$mm (middle of the target) at different times during the implosion.