

Prospects of High-Energy-Density Matter Research at GSI Darmstadt and Future FAIR Facility

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Abstract: Gesellschaft für Schwerionenforschung (GSI), Darmstadt is a unique laboratory worldwide that has a heavy ion synchrotron, SIS18 that delivers intense beams of heavy ions including uranium. Currently the SIS18 can deliver 4×10^9 uranium ions in a single bunch that is a few hundred ns long. This facility is being upgraded with the aim to achieve an intensity of 2×10^{11} uranium ions with a bunch length of 50 ns. Moreover, the German Government has recently approved construction of a new accelerator facility named **FAIR** (Facility for Antiprotons and Ion Research) at the GSI that will involve construction of a much more powerful synchrotron, SIS100. The design parameters of the SIS100 beam include a beam intensity of 2×10^{12} uranium ions and a bunch length of the order of 50 ns.

Detailed theoretical studies including sophisticated numerical simulations and analytic modeling have shown that the ion beams generated at the GSI facilities can be used to study the thermophysical properties, especially the equation of state (EOS) of high energy density (HED) matter. In one scheme named **HIHEX**, a piece of material is isochorically heated and then allowed to expand isentropically passing through very interesting physical states of HED matter which are either very difficult to access or are even inaccessible using traditional methods of shock compression. The second method named **LAPLAS** (LABoratory PLANetary Sciences) involves low entropy compression of a sample material like hydrogen that is enclosed in a shell of heavy material like gold and the target is imploded by a hollow beam that has an annular focal spot. Calculations show that one can achieve physical conditions that are expected to exist in the interiors of the giant planets. These two experimental schemes are the basis for the letter of intent named **HEDgeHOB** (High Energy Density Matter Generated by Heavy Ion Beams), written by the GSI Plasma Physics Group in connection with the future FAIR facility.

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