High Energy Density Experiments at FAIR

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The Facility for Antiproton and Ion Research (FAIR) will offer unique research opportunities in the field of plasma physics. This research will focus on the study of high energy density matter generated with heavy ion beams.

The equation of state of high energy density matter is important for many scientific fields, ranging from studying the interior structure of giant gas planets and the metallization of hydrogen to the dynamics of laser-driven capsules for inertial confinement fusion. To better understand the relevant processes, knowledge of the equation of state and of the transport coefficients of states with high energy density (eV temperatures and near solid density) is essential. The experiments at FAIR will focus on these measurements.

At FAIR, the SIS-100 heavy ion synchrotron will provide heavy ion beams with up to $5*10^{11}$ U^{28+} ions with 2 AGeV in a 50 ns bunch for plasma physics experiments. These ion beams can be used to isochorically heat macroscopic (mm-sized) samples and turn them into warm dense matter with eV temperatures (e.g in the HIHEX experiment [1,2]). Alternatively, the heavy ion beams can be used to indirectly compress cryogenic samples. By using an annular beam profile to heat a payload, it is possible to quasi-isentropically compress hydrogen to Mbar pressures at sub-eV temperatures, as planned in the LAPLAS experiment [2].

SIS-100 will not only provide heavy-ion beams, but also high-energy protons (up to 10 GeV with up to $2.5* 10^{13}$ protons per bunch). These proton beams will be used to diagnose dense samples using a proton microscope with a resolution of 10 µm (PRIOR [2,3]). The proton microscope can be used to either study high-energy density matter generated with secondary drivers (e.g. a laser or a gas gun) or for other applications such as imaging biological samples [4].

Experiments using the SIS-100 heavy ion synchrotron are scheduled to start in 2022. Before that (2018-2021) it is planned to carry out first experiments using the upgraded UNILAC and SIS-18 accelerators at GSI (“Phase 0”). The interim science program (“Phase 0”) at GSI (using PHELIX, UNILAC and SIS-18) and at other facilities is essential for further R&D work, and to keep up with technological and scientific progress until the start of FAIR. Activities in this phase will include the further development of PRIOR and work on diagnostics, such as laser particle acceleration, as well as other experiments that do not require the beam intensity of SIS-100. With the start of SIS-100, the experiments of the Modularized Start Version will begin, initially with reduced beam intensity (“Phase 1”) and later on with the full beam intensity (“Phase 2”).

In my presentation I will give an overview of the experimental facilities and of the planned experiments at FAIR.

References

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