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Exploring dense nuclear matter with heavy-ion collisions

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Nucleus-nucleus collisions provide a unique opportunity to create and to investigate dense nuclear matter in the laboratory. These experiments address fundamental aspects of strong-interaction physics: the nuclear equation-of-state at high baryon densities, the in-medium modifications of hadrons, and the phase transition from hadronic to partonic degrees of freedom. These phenomena play an important role for the dynamics of core-collapse supernovae, and for the structure of neutron stars.

Nuclear matter densities of up to three times saturation density can be produced in heavy-ion collisions at GSI in Darmstadt/Germany. Experiments found evidence for a soft nuclear equation of state using kaons as diagnostic probe. Moreover, the yield and the emission pattern of strange mesons indicate that the properties of kaons and antikaons are modified in dense nuclear matter.

Even more extreme conditions will be created in heavy-ion collisions at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt. Here, the goal of the experiments is to explore the QCD phase diagram in the region of the highest baryon densities, where a transition to quark matter is expected. This approach is complementary to the experiments at RHIC and LHC, where matter at very high temperatures but vanishing net baryon density is produced. The future heavy-ion program at FAIR will be discussed.

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