Initial state and early evolution in relativistic heavy-ion collisions.

During a relativistic heavy-ion collision a fireball of hot and dense matter is created. The reaction dynamics can be described using relativistic viscous hydrodynamic models. Such models reproduce fairly well the experimentally observed particle distributions. This conclusion is surprising, because formally hydrodynamics can be applied only if microscopic scales, such as the mean free path, are much smaller than the macroscopic scales, over which the macroscopic quantities change. However, in nuclear collisions gradients of density and velocity are large. This is even more true in proton-nucleus collisions where the hydrodynamic model seems to work as well.

Model studies of nonequilibrium dynamics indicate that nonequilibrium corrections to the dynamics are large at the early stage of the collision. At the early stage, matter expands very fast in the longitudinal direction, along the beam axis. This rapid expansion causes a noticable asymmetry of the effective pressure in the system. The longitudinal pressure is much smaller than the transverse one. It is striking that no direct experimental indication of such nonequilibrium effects has been found up to now.

The aim of the project is to find experimental signatures of the non-equilibrium pressure asymmetry at the early stage of the collision. We propose to study two such quantities. The first one is the directed flow in noncentral collisions. The directed flow describes the preference of particles to be emitted in a particular direction transverse to the collision axis. This preferred transverse direction is opposite for particles going forward and backward in the longitudinal direction. This effect comes from an interplay of the longitudinal and transverse pressures. The second proposed signal is the asymmetric diffusion of charges in the medium. A quark-antiquark pair created in the early stage diffuses in the medium. In case of pressure asymmetry the diffusion will be stronger in transverse than in the longitudinal direction.

Possible observation of non-equilibrium effects will help in understanding the mechanism of the production of dense matter, the quark-gluon plasma. Estimating the relaxation time for pressure equilibration will tell whether non-equilibrium quantum chromodynamics is described by a strongly interacting field theory or by kinetic equations.