The goal of the project is to find a description of quark-gluon plasma valid at very early times in its evolution. Here on Earth quark-gluon plasma is a kid of fluid which is produced in experiments where heavy nuclei collide in accelerators such as the Relativistic Heavy Ion Collider (RHIC) at Brookhaven, or in the ALICE experiment at the LHC at CERN. In the aftermath of a nuclear collision typically tens of thousands of particles are registered. Already Fermi and Landau in the 1940s and 1950s had guessed that a statistical approach in terms of relativistic hydrodynamics should apply. Almost 15 years ago these expectations were decisively confirmed. It was not obvious that they would be, since we expect that at sufficiently high collision energies we should see a gas of weakly interacting quarks and gluons: this expectation follows from asymptotic freedom, which is one of the basic features of the strong force. However both at RHIC and the LHC we clearly observe collective effects characteristic of fluids, not gases: the distributions of detected particles carry information about the collision geometry (this is the so called "elliptic flow"). The fluid is called quark-gluon plasma, even though it is far from clear whether one can in a useful way regard it as a collection of individual quarks and gluons rather than a quantum state which does not possess such a particle description. It is also significant that the flow of quark-gluon plasma is dissipative: it is associated with entropy increase. This effect is due to viscosity of the fluid. It turns out that the viscosity of quark-gluon plasma is small relative to its entropy density, and for this reason one sometimes speaks of "the most perfect fluid in nature". It is also worth noting that in the ALICE experiment the temperature of quark-gluon plasma exceeds 5 trillion degrees!

The fundamental theory of the strong interactions, quantum chromodynamics (QCD), is a difficult theory to solve, and we do not have the mathematical tools necessary to effectively use it to describe quark-gluon plasma in a quantitative way. Fortunately, a phenomenological description in the language of relativistic hydrodynamics does not require that we first solve QCD. It is however an extremely important task to derive the hydrodynamic description from the microscopic theory, even in some approximate way. In this project we will study this problem in models which shares some features of QCD, but have the advantage of admitting effective mathematical methods which allow us to calculate. Even though the results of these calculations do not apply directly to the real world, they do give at least a qualitative picture which may eventually lead to physically relevant predictions. An important example of such a model is N=4 supersymmetric Yang-Mills theory. Just like QCD, this theory describes strong interactions as consequence of gluon exchange. However instead of quarks, this theory has a specially chosen set of degrees of freedom, both fermionic and bosonic. In consequence this theory is rather unusual: it is in fact a specific solution of string theory! This fact makes it possible to represent it in a completely different ("dual") way, which allows us to calculate observables (in the sense of quantum mechanics) using classical (not quantum!) methods. Since this dual representation makes use of an extra spacial dimension, one speaks of the two representations as being holographically related. Holography is a very fundamental feature of string theory, which in this context is used as a computational method.