Summary of the Dissertation (English version)
Thermodynamic methods for relativistic hydrodynamics

Lorenzo Gavassino (lorenzo.gavassino@gmail.com)
Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warsaw, Poland

Relativistic hydrodynamics is an essential tool for modelling many astrophysical systems, including accretion disks, neutron stars, and the Universe itself. Hydrodynamic simulations are the only means by which we can extract solid quantitative predictions for high-energy astrophysical phenomena, such as supernovae, jets, and neutron star mergers.

We can consider relativistic hydrodynamics as the point of intersection of thermodynamics and classical field theory. Unfortunately, implementing the irreversible character of the first, in a way that is consistent with the mathematical requirements of the second (e.g. causality and well-posedness of the initial value problem), is a difficult task. Many differential equations, which seem to be physically motivated (such as the heat equation), are not exploitable as relativistic field theories.

This work addresses two major open problems in relativistic hydrodynamics: thermodynamic consistency (i.e. making sure that all thermodynamic principle are obeyed) and stability (i.e. making sure that fluids do not depart spontaneously from thermodynamic equilibrium). We develop several methods and diagnostics for testing whether a theory is physically meaningful, and well suited for numerical implementation. The most important result of the thesis is that, for a large class of theories, stability is mathematically equivalent to thermodynamic consistency.