

# Sudden and violent relaxation in plasmas and gravitational systems

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## Coronal heating problem

The atmosphere of the sun can be divided into two parts. The inner part consists of the Photosphere and the Chromosphere in which the plasma is dense and is at a temperature of approximately 4000-10000K. The outer region, called the corona, consists of a less dense but warmer plasma and is at a temperature of approximately 1-2 million K. Such an inverse temperature gradient approximately marks the height at which the plasma becomes collisionless (Figure 1). Since the layers at the basis of the atmosphere (Photosphere and Chromosphere) are at a lower temperature than the corona, for the second principle of thermodynamics they cannot directly heat corona. How can a collisionless plasma achieve such high temperatures is a fundamental unsolved problem of Solar Physics and Plasma Physics, and it is known as the coronal heating problem.

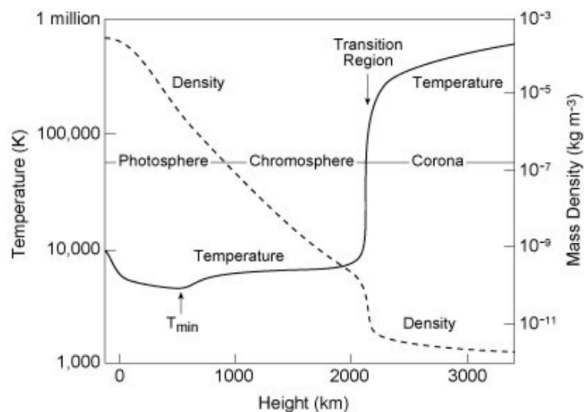


Figure 1: Temperature variations (left y axis) and density variations (right y axis) as a function of height above the solar surface

## Prospects for the project: temperature inversion and violent relaxation

Recently it has been shown, in the context of a self-gravitating particles system, that bringing a system out of thermal equilibrium by a violent injection of energy, leads towards a non equilibrium stationary configuration in which the temperature profile presents a gradient opposite to that of density, as it happens in the solar atmosphere (Figure 1). This relaxation process is called violent relaxation and is a typical scenario of collisionless systems with long-range interactions. In this project, we want to understand if the violent relaxation of self-gravitating particles system can be generalised to plasmas in order to explain the coronal heating problem. Specifically, we aim to reach the following objectives:

- Determine if upon a violent injection of energy a thermal bath of fully-ionized plasma in an external gravitational field can relax to a stationary configuration characterized by a temperature profile with a gradient opposite to that of density (a corona).
- Determine the properties of the energy input in the dense Chromosphere that can lead to the formation of an inverse temperature gradient.

The results obtained can be compared with the new data from Solar Orbiter and Parker Solar Probe, since the corona naturally evolves into the solar wind that is directly measured by the above spacecrafts.