One of the most solid and justified candidates to explain the nature of dark matter is the axion. The axion appears as an unavoidable consequence of dynamical solutions to a major long-standing fundamental puzzle of the Standard Model of Particle Physics (SM). This is the so-called strong CP problem: the strong interactions of the SM (QCD), responsible for holding together the proton, neutron and nuclei of matter, have a parameter characterising its vacuum whose physical value needs to be adjusted by over ten orders of magnitude for no apparent reason. The present experimental search for axions is very intense. Outstandingly, and after a long historic quest, many axion experiments and noticeably ADMX in the USA, have very recently reached the region in sensitivity where the axion may be expected, a fact that has electrified the community as a discovery would be revolutionary. At the same time, no completely satisfactory axion theory exists yet. Furthermore, the phenomenological signals explored up to now are mainly axion couplings to photons, gluons and fermions, while other possible interactions predicted remain rarely considered. The thesis would first provide the student with a perspective on the evidence for dark matter on one side, and with an understanding of the theoretical tools and SM aspects of the strong CP problem on the other side. Existing axion models would be then explored aiming to the development of a new improved model, as well as to the exploration of new phenomenological signals at high and low energy experiments.