Título: SOLAR AXION SEARCH WITH MICROMEGAS DETECTORS IN THE CAST EXPERIMENT USING 3HE AS BUFFER GAS

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Resumen: Axions are well motivated particles proposed in an extension of the Standard Model (SM) as a solution to the CP problem in strong interactions. On the other hand, there is the category of axion-like particles (ALPs) which appear in diverse extensions of the SM and share the same phenomenology of the axion. Axions and ALPs are hypothetical neutral particles that interact weakly with matter, being candidates to solve the Dark Matter problem.

CAST, the CERN Axion Solar Telescope is looking for solar axions since 2003. CAST exploit the helioscope technique using a decommissioned LHC dipole magnet in which solar axions could be reconverted into photons. The magnet is mounted on a movable platform that allows tracking the Sun ~1.5 hours during sunset and during sunrise. The axion signal would be an excess of X-rays in the detectors located at the magnet bore ends and thus low background detectors are mandatory. Three of the four detectors operating at CAST are of the Micromegas type. The analysis of the data of the three Micromegas detectors during the 2011 data taking campaign at CAST is presented in this thesis, obtaining a limit on the coupling constant of gag < 3.90 x 10-10

GeV-1 at a 95% of confidence level, for axion masses from 1 to 1.17 eV.

CAST Micromegas detectors exploit different strategies developed for the reduction of the background level: the intrinsic radiopurity of the detectors; the improvements on the manufacturing process; the event discrimination and the shielding. Moreover, different test benches have been developed in order to understand the origin of the background, in which the set-up at the LSC (Laboratorio Subterráneo de Canfranc) is the one that shows the lower background level. The state of art in low background techniques is shown in the upgrades of the Micromegas detectors at CAST, described in this work, which has led to a reduction of a factor ~6 of the background levels in the Micromegas detectors. It translates in an improvement of the sensitivity of CAST in a factor ~2.5.

Beyond CAST a new generation axion helioscope has been proposed: IAXO-the International Axion Observatory. IAXO will enhance the helioscope technique by exploiting all the singularities of CAST implemented into a large superconducting toroidal magnet, dedicated X-ray optics and ultra-low background detectors attached at the end of the magnet bores. A description of the IAXO proposal and the study of the sensitivity of IAXO are presented in this thesis. IAXO will surpass the sensitivity of CAST in more than one order of magnitude, entering into an unexplored parameter space area and by first time in a favored region for axions and ALPs.

The use of thin cavities inside long magnets for relic axion detection is particularly appealing, because this type of magnets are already used by the axion community in experiments looking for solar axions, like CAST and are projected in future searches like IAXO. A directional effect could be observed by the use of long thin cavities properly tuned. This case has been studied in this thesis and could provide a strong identificative signature of the direction of the CDM axions.