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Search for high energy axions with the CAST calorimeter

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The observed CP conservation, in the strong interactions is an unexpected and unresolved feature of the theory of QCD. The introduction of a new $U(1)$ symmetry can resolve this so-called "strong-CP problem". This symmetry, however, leads to a new boson, the axion, which is predicted to couple to photons and nucleons and may be produced in the nuclear and plasma processes of stars. The CERN axion solar telescope (CAST) experiment is designed to detect such solar axions by converting them into real photons in a magnetic field. We focus on the CAST γ-ray calorimeter which extends the sensitivity of the CAST experiment into the MeV region by searching for an excess signal during solar alignment due to high energy axions emitted in nuclear processes in the sun. The large increase in "axion luminosity" provided by the sun and the increased axion-to-photon conversion probability in the refurbished LHC magnet make the CAST experiment uniquely sensistive to an axion signal. In the case of zero signal above background, background subtraction from the solar alignment "tracking" data allows a direct search for anomalous excess events. Using existing helioseismology limits on the axion flux from the sun, the mass and photon-coupling of an axion or new axion-like boson are constrained using limits on the observed flux of axions in the detector. In this way, limits are obtained without requiring detailed knowledge of nuclear mixing matrices for each production mechanism and the CAST helioscope search can be extended beyond specific nuclear transitions and can consider nuclear axion emission from the sun more generally. For a 5.5 MeV axion-photon conversion spectrum, which is a highly motivated channel, the limit on the axion-to-photon coupling obtained is $g_{a\gamma\gamma} \leq 2 \times 10^{-9}$ GeV^{-1} for $0.1 \leq m_a \leq 0.9$ eV, which is are slightly more restrictive than both the current experimental limits as well as those from helioseismology.

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