International Axion Observatory (IAXO)

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1 Goal of experiment

The main goal is the search for solar axions (and axion-like particles, ALPs) in a broad axion mass range with sensitivity down to a few $\times 10^{-12}$ GeV^{-1}, an improvement up to 1.5 orders of magnitude in $g_{a\gamma}$ compared to that measured by the CERN Axion Solar Telescope (CAST), currently the most powerful implementation of the axion helioscope concept. The region of parameter space probed the International Axion Observatory (IAXO) would include a large fraction of realistic, previously unexplored, QCD axion models at the meV mass scale and above. IAXO will complement the region of parameter space to be explored by axion dark matter haloscope searches.

2 Experimental setup

The IAXO experimental setup follows Sikivie's helioscope concept [1], extended with the use of x-ray optics and low background detectors [2], as was pioneered by CAST[3]. IAXO will require a new toroidal magnet with substantially increased magnetic volume with respect that of CAST. Photons created from axion conversion in the magnet will be focused by large aperture x-ray optics, built using cost-effective techniques based on thermally formed glass substrates, an approach successfully used in x-ray astronomy missions like NuSTAR [4]. Finally, the focused x-rays are detected by several systems, using state-of-the-art low background techniques like the ones offered by the high granularity gaseous Micromegas detectors developed in CAST. These detectors consist of radiopure components and highly efficient shielding and utilize powerful offline discrimination based on the topology of the events in gas. Besides this core experimental setup, further instrumentation may be added to test additional physics beyond QCD axions.

All of the technologies required for IAXO are well-proven and need no further R&D to validate their operation. However, a cycle of design study and prototype construction will allow the IAXO team to optimize, refine and specify final performance requirements of each subsystem.

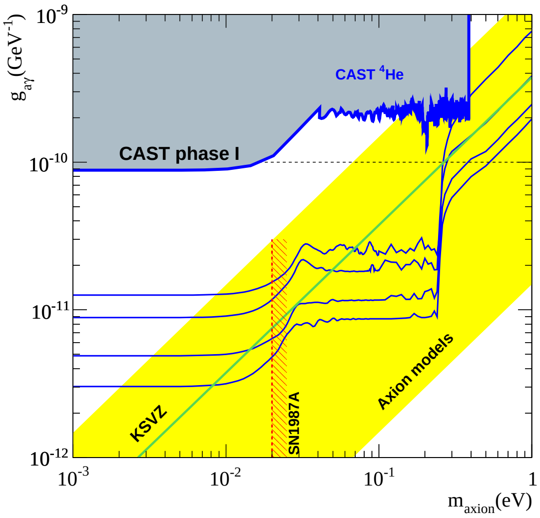

Figure 1: The parameter space for hadronic axions and ALPs. The CAST limit, some observational limits, and the range of PQ models (yellow band) are also shown. The blue lines indicate the sensitivity of the four scenarios for IAXO ranging from more conservative to more optimistic prospects. See [2] for more details.

3 Accelerator or Lab Facility

Due to the experience developed with CAST, CERN is a leading candidate for where to site IAXO. However, no formal decision has been made and any institution that has sufficient infrastructure to support cryogenic operation and the conventional facilities could host IAXO. The experiment does not make use of an accelerator.

4 Physics Reach

IAXO will achieve sensitivity to solar axions (and axion-like particles, ALPs) in a broad axion mass range and down to a few $\times 10^{-12}$ GeV^{-1}, in particular, including realistic, previously unexplored, QCD axion models at the meV mass scale and above. This sensitivity represents an improvement up to 1.5 orders of magnitude in $g_{a\gamma}$ over the limit observed with the CERN Axion Solar Telescope, currently the most powerful implementation of the axion helioscope concept. See left of figure 1.

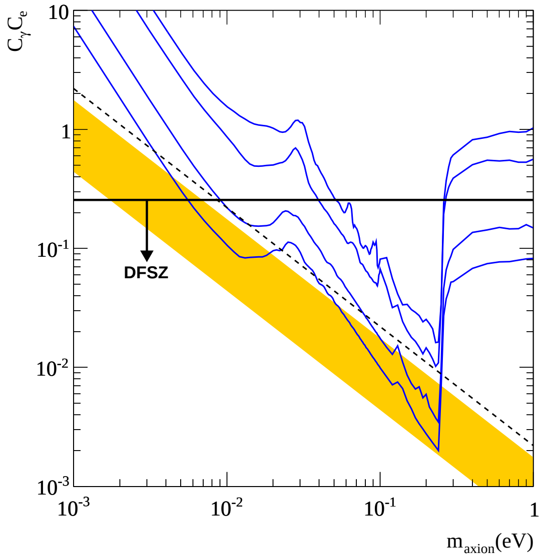

Figure 2: The expected sensitivity regions of the four same scenarios in the parameter space of non-hadronic axions with both electron and photon coupling. In GUT models C_γ is fixed to 0.75 and we show the bound on the electron coupling (C_e) from red giants (dashed line along the diagonal) and the region motivated by WD cooling (orange band). DFSZ models lie below the horizontal line $C_\gamma C_e < 0.25$. From [2]

Additionally, IAXO will provide sensitivity to other more specific models of hidden scalars. Generic models of very light ALPs invoked in a number of astrophysical unexplained observations can also be directly tested. Specific electron-coupled QCD axion models invoked to explain the White Dwarfs (WD) cooling anomaly could also be partially probed through the direct detection of the same axion bremsstrahlung emission in our Sun, as shown on the right of figure 2. Finally, the possibility to search for dark matter axions with additions to the core IAXO apparatus is being explored.

We refer to [2] for more details.

5 Status and Schedule

The experiment has published an initial paper that highlights the physics case, expected sensitivity and first feasibility results. The collaboration is at the moment working to produce a Conceptual Design Report, and a formal proposal in the coming months.

6 Future Plans

The collaboration will present IAXO at forthcoming conferences of our field, and will participate in community-wide workshops and roadmapping exercises, including:

- DOE Intensity Frontier Workshop (Dec 2011)
- NSF+DOE Axion Workshop (Apr 2012)

Senior members of the collaboration will continue socializing with Program Managers from:

- CERN
- ASPERA
- DOE
- NSF

7 Collaborating Institutions and Collaborators

The collaboration is in the process of growing and getting formalized. Active groups or groups having shown interest include: CEA/Saclay, CERN, Columbia U., Demokritos, DESY, DTU-Space, INR Moscow, LLNL, U. Patras, RBI Zagreb, U. Trieste, TU Darmstadt, Yale and U. Zaragoza. Additionally, some researchers from Fermilab have had preliminary discussions regarding new high field magnet designs.
The collaboration will gladly consider contributions and participation from other institutions and interested parties should contact the IAXO Spokesperson Igor Irastorza.

8 Written Materials (e.g. references)

JCAP 1106 (2011) 013

9 Any other info?

References

[1] P. Sikivie, *Experimental tests of the *invisible* axion*, *Phys. Rev. Lett.* **51** (1983) 1415.

[2] I. Irastorza, F. Avignone, S. Caspi, J. Carmona, T. Dafni, *et. al.*, *Towards a new generation axion helioscope*, *JCAP* **1106** (2011) 013, [`arXiv:1103.5334`]. * Temporary entry *.

[3] **CAST** Collaboration, K. Zioutas *et. al.*, *First results from the CERN Axion Solar Telescope (CAST)*, *Phys. Rev. Lett.* **94** (2005) 121301, [`hep-ex/0411033`].

[4] F. A. Harrison, S. Boggs, F. Christensen, W. Craig, C. Hailey, D. Stern, *et. al.*, *The nuclear spectroscopic telescope array (nustar)*, *Proceedings of the SPIE* **7732** (2010) 77320S–1–8.