The strong CP problem of the Standard Model of particle physics is solved by the introduction of an additional symmetry to the Standard Model, the Peccei-Quinn symmetry. A natural consequence of this solution is the existence of a pseudoscalar particle called the axion, which is also a viable candidate for the dark matter.

Since stellar plasma is a powerful source of axions, the Sun being our star is the best place to look for axions. Solar axions are produced in the Sun by the interaction of a few keV blackbody photons (or transverse plasmons) with the electric field of the plasma, i.e. via the Primakoff effect. The strength of the solar axion flux is proportional to the square of the axion-photon coupling, \((g_{a\gamma})^2\). The CERN Axion Solar Telescope (CAST) is designed to reconvert solar axions back into X-rays via the inverse Primakoff effect, which is possible in a transverse magnetic field \((B)\) over a certain length \((L)\). Here the axion-photon conversion probability is proportional to \((B.L)^2\). With this respect, CAST is more powerful by 2 orders of magnitude compared to earlier helioscope experiments. This is achieved by the use of an LHC magnet with two parallel pipes of length 9.26 m and of diameter 43 mm, producing a magnetic field of 9 T at the interior of its pipes when operated at 1.8 K.

Besides a high conversion rate, a strongly reduced detector background is required because the axion-photon reconversion manifests itself as excess photons in the detectors over background photons collected during the rest of the day. CAST currently uses 3 high technology micromesh gas detectors (micromegas) and a charge-coupled device (CCD) with an X-ray focusing mirror.

During Phase I of the experiment, the magnet was operated for about 1 year with its pipes evacuated. Without any significant excess photons observed within an explored mass range up to \(~0.02\) eV, this phase set an upper limit of \(8.8 \times 10^{-11}\) GeV\(^{-1}\) on the axion-photon coupling.

The sensitivity of the experiment was extended in Phase II by filling the pipes with a buffer gas. The pipes were filled with \(^4\)He in the first part and with \(^3\)He in the second part of Phase II, allowing to explore a parameter space favored by theoretical axion models. Buffer gas behaves as non-relativistic plasma for X-rays, so X-rays from converted axions acquire an effective mass equal to the plasma frequency of the gas. When the effective mass of the photon (or plasmon) is roughly equal to the mass of the axion, the probability of inverse Primakoff conversion is sharply maximized, because the momentum transfer during the conversion is negligible. In the first part of this phase, where \(^4\)He was used as a buffer gas, an axion mass range up to \(~0.4\) eV was explored by changing the pressure, i.e. the density, of the gas inside the pipes such that the effective mass of the plasmon was adjusted to the relevant value. Naturally, the pressure inside the pipes was changed in discrete steps. But, the size of the steps was chosen such that CAST was sensitive to all axion masses in its range. The high precision of the pressure change was achieved by the use of metering volumes which control the flow of the gas into the pipes. With 160 different pressure setting, an upper limit of \(2.17 \times 10^{-10}\) GeV\(^{-1}\) was set on the axion-photon coupling for \(m_a<0.4\) eV, at a pressure of \(~13.4\) mbar (see Fig.1).

To be able to scan axion masses larger than the final value of the first part of Phase II, \(^3\)He was used instead of \(^4\)He as a buffer gas, in which X-rays would acquire a larger effective mass. Necessary technological modifications to the experiment were done during 2007 and the second part of Phase II began in the beginning of 2008. Use of \(^3\)He required the installation of a recuperation volume on top of the magnet in order not to lose this very expensive gas in case of quench (see Fig.2 for the gas system of Phase II with \(^3\)He). Now, the aim is to scan all the axion mass values larger than 0.4 eV up to 1.2 eV,
changing the pressure from 13.4 to 120 mbar in appropriate steps. By the end of 2008 CAST scanned upto 0.6 eV axion rest mass. During Phase I and the first part of Phase II, pressure was changed once a day. But, during the second part of Phase II, pressure is being changed in the middle of each solar tracking so that a larger range of mass values is scanned without significant loss of statistics while all detectors are sensitive to each pressure setting.

Figure 1 Exclusion plot of Phase II with $^4$He

Figure 2 Gas system of Phase II with $^3$He