Status of the ALPS Experiment

The ALPS collaboration has concluded successfully its data taking end of 2009. The final results are published in http://dx.doi.org/10.1016/j.physletb.2010.04.066 and have also been mentioned in *Nature* (http://www.nature.com/nature/journal/v465/n7296/full/465271c.html). Up to now the sensitivity of ALPS has not been surpassed by any other laboratory experiment. However, there is hardly any means to improve the existing set-up considerably. Hence the collaboration is on its way to re-organize itself to work out a TDR for a large scale "light-shining-through-a-wall" experiment. The current status is described below starting with an overview on the WISP scene worldwide.
The sketch of a future experimental set-up is not repeated here. Nothing essential has changed since our last report to PRC in April 2010 which is attached to this document.

Phenomenological and experimental WISP activities

The worldwide interest and activity in axions and other WISPs is still growing. An important event since the last PRC meeting was the 6^{th} Patras Workshop on Axions, WIMPs, and WISPs, which took place from July 5-9, 2010, in Zürich (http://axion-wimp.desy.de/), which gathered about 80 participants. As can be seen from the transparencies available through the webpage above, the light-shining-through-a-wall (LSW) experiments at CERN, Fermilab, and JLab all have strong ambitions to improve their sensitivity to various WISPs in a new generation of their setups. There is consensus in the axion community that the most important target for the next generation of LSW experiments is to reach a sensitivity in the 10^{-11} GeV^{-1} range in the two photon coupling of a hypothetical ultra-light axion-like particle (http://dx.doi.org/10.1063/1.3489551). Such a coupling is expected in popular intermediate string scale scenarios. Moreover, an ultra-light ALP with such a coupling would explain the non-observation of a cutoff in TeV photon spectra of distant active galactic nuclei (AGNs) due to pair-production on the extragalactic background light. This target can only be reached by exploiting many superconducting magnets available at accelerator labs as well as resonant cavities both on the generation as well as on the regeneration side of the experiment. Here, the finite aperture of available magnets (HERA, LHC, Tevatron) pose constraints on the transversal extent of optical modes that can be used in the cavities and this in turn limits the length of the whole experiment by the beam's divergence. Taking this into account, one finds that, with HERA magnets, one may reach an optimal sensitivity of 9.8 10^{-12} GeV^{-1}, by exploiting strings of 20 + 20 magnets (http://arxiv.org/pdf/1009.4875).

Another very active area is in microwave cavity experiments, both in the form of microwave-shining-through-a-wall experiments, as originally proposed in http://dx.doi.org/10.1016/0370-2693(92)91977-H for ALPs and in http://dx.doi.org/10.1016/j.physletb.2007.11.071 for hidden photons, as well as in the form of haloscopes, as originally proposed in http://dx.doi.org/10.1103/PhysRevLett.51.1415. In fact, the first pioneering experiments in the former category, searching for hidden photons, have been performed (http://arxiv.org/pdf/1003.0964 , http://arxiv.org/pdf/1007.3766) and more, also searching for ALPs, are to be commissioned (see the talks at the 6^{th} Patras Workshop). A very interesting idea for a new superconducting microwave cavity based haloscope has been put forward recently (http://arxiv.org/pdf/1009.0762). This experiment would be sensitive to the QCD axion in the mass range expected in intermediate string scale scenarios and thus be nicely complementary to the next generation of optical LSW experiments.

Toward an ALPS-II TDR

Brief sketches in the main areas of the experiment (laser and cavities, detector, magnets, infrastructure) are given.

Laser and cavities

The current activities at the Albert-Einstein-Institute (AEI) in Hannover related to the ALPS II experiment are focused on the advance of the optical system and the necessary pre-experiments to demonstrate the feasibility of the intended optical design. To this end, the overall design of the optical system has been concretized and improved. The characteristics of the coupling efficiency between the optical cavities have been analyzed. Currently, alternative stabilization schemes for the cavities are considered as well as possible improvements that can be made concerning the regeneration efficiency.

A design for a preliminary version of an attenuation box preceding the single photon detection in order to obstruct green light from the detector has been shaped. The device is embedded in a planned experimental exclusion test for down-converted infrared photons potentially generated by the green control beam used to stabilize the regeneration cavity. The realization of this pre-experiment is currently prepared.

The personal in this part of the experiment has been strengthened significantly by two PhD students (one from AEI and one from DESY).

Detector

A decision on the detection scheme has not been taken yet. In principle ALPS-II could use very low noise single photon counters or a heterodyne detection scheme. Statistical considerations for both schemes are in progress to compare the reachable sensitivities. However, a final decision has to wait for a conclusion on the implementation of the cavities mentioned above.

We are following two approaches for a single photon counter. One relies on a CCD system similar to the one exploited for ALPS before. The other one concentrates on a superconducting Transition Edge Sensor (TES). A TES should allow for nearly background free “real time” single photon counting with about 10% energy resolution. While the energy resolution has been demonstrated several times already, only upper limits of 10^{-3} Hz exist for dark count rates. At present we are setting up a small collaboration of DESY and Hamburg University (SQUID electronics for read-out), INFN and University Trieste (bonding and experimental set-up), INFN and University Genova (TES sensor) as well as Camerino University (cryostat) to get expertise in TES application and to measure TES properties (especially dark count rates and detection efficiencies). A corresponding proposal by the Italian groups is likely to be granted (preliminary information) so that the work could start end of this year. Results should be available in summer 2011.

Two PhD students at DESY have started their work on detector and data analysis issues.

Magnets

An experienced physicist from DESY's accelerator division has joined ALPS and is in charge of working out the TDR part describing the ALPS magnet set-up including the required infrastructure. The usage of HERA and LHC dipoles will be considered.

Infrastructure

Space of offices and laboratories (a clean room is to be set up for optics tests) has been identified, but final decisions have not been taken yet. Problems are not anticipated here.

Summary

The ALPS collaboration is reforming and has strengthened considerably with international participation in the detector development. We are confident that this will enable us to proceed along the schedule presented to the PRC in spring 2010.

The PRC is asked to take note of this development. More details including a schedule and resource planning are to be presented at the PRC meeting in spring 2011.

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