**LIGHT PSEUDO-SCALAR AND SCALAR PARTICLE SEARCH (LIPSS)**

**O. K. BAKER FOR THE LIPSS COLLABORATION**

# 1 Goal of experiment

Sensitive search for new phenomena that are beyond the Standard Model of particle physics and that have scalar, pseudo-scalar, vector, or tensor couplings to photons. This includes any type of sub electron volt weakly interacting particle or field.

# 2 Experimental setup

The experiment has two components. (1) Sensitive searches using the method of photon regeneration (sometimes referred to as 'light shining through a wall') where photons upstream of an optical barrier may couple to new BSM particles. The latter would proceed unimpeded through the barrier ('the wall') while the optical photons cannot penetrate it. And photons detected downstream of the barrier would be the result of the BSM particle reconverting to a photon. See the attached Figs 1(a) and 1(b). (2) Sensitive searches for primordial halo particles that were created in the early universe and that have couplings to photons. Including searches for dark matter axions, and other weakly interacting sub electron volt mass particles. The measurements require sensitive photon detectors in various photon energy ranges, and in some cases very strong magnets. There is ongoing technology development in both cases.

# 3 Accelerator or Lab Facility

The initial experiment used the Free Electron Laser (FEL) at Jefferson Lab (JLab), the world's most powerful tunable laser. The next phase of the experiment takes place on the Yale University campus using an intense radio frequency source of millimeter wave photons, high field magnets, and resonant cavities with the associated electronics and infrastructure. Both types of experiments listed in the previous section are implemented on the campus using the same experimental setup. This latter experiment may be moved to JLab to use its Terahertz light facility at the FEL in the future.

Some aspects of the experiment will benefit from the development of high field magnets and more powerful tunable lasers such as the Megawatt-class lasers under consideration in industry currently.

## 4 Physics Reach

There are several new results that have been published by the LIPSS team, based upon data taken at the JLab FEL, and other collaborations. See figures in the references below for physics reach.

## 5 Status and Schedule

The initial phase of the JLab FEL experiment has been completed, and the results published. New data using the experimental setup on the Yale campus is currently being collected, using resonant microwave cavities in the region of 34 GHz. It is expected that this newest data will be collected and analyzed over the next year. Afterwards, a new cavities at different frequencies will be constructed and used to collect data for different particle masses.

## 6 Future Plans

Future plans include the use of more sensitive detectors, more powerful magnets, and new resonant cavities at various wavelengths to more completely cover the unexplored parameter space (coupling versus mass). The development of ultra-low background noise, high efficiency detectors in the range of tens of GHz and higher is an area of great commercial and medical interest, as examples. The accelerator and NMR community is interested in the development of higher field strength, large bore magnets. Additional plans include the use of quasi-optical cavities that are useful at Terahertz frequencies.

## 7 Collaborating Institutions and Collaborators

LIPSS Collaboration at the JLab FEL

A. Afanasev, **George Washington University and JLab**

**G. Biallas, J. Boyce, M. Shinn, Jefferson Lab**

**K. Beard, Muons, Inc**

**O.K. Baker, P. Slocum, Yale University**

**Yale Microwave Cavity Experiment Collaboration**

**O.K. Baker, Y. Jiang, S. Kazakov, M.A. LaPointe, A.T. Malagon, A.J. Martin , S. Shchelkunov , P. Slocum, A. Szymkowiak, Yale University**

**J.L. Hirshfield , Omega P and Yale University**

**G. Kazakevitch, Muons, Inc.**

## 8 Written Materials (e.g. references)

**Sensitive search for axion-like particles and hidden sector photons using copper resonant cavities. Penny L. Slocum, O.K. Baker, J.L. Hirshfield, Y. Jiang, G. Kazakevitch, S. Kazakov, M.A. LaPointe, A. Martin, S. Shchelkunov, A. Szymkowiak, (Yale U.) . DESY-PROC-2011, 2011. 4pp. Prepared for 7th Patras Workshop on Axions, WIMPs and WISPs, Mykonos, Greece, Jul 2011.**

**Measurements in search for 0.1-meV axion-like particles and hidden sector photons using copper resonant cavities. Penny L. Slocum, O.K. Baker, J.L. Hirshfield, Y. Jiang, G. Kazakevitch, S. Kazakov, M.A. LaPointe, A. Martin, S. Shchelkunov, A. Szymkowiak, (Yale U.) . DESY-PROC-2010-03, Nov 2010. 4pp. Prepared for 6th Patras Workshop on Axions, WIMPs and WISPs, Zurich, Switzerland, 5-9 Jul 2010. Published in *Zuerich 2010, 6th Patras Workshop on Axions, WIMPs and WISPs* 45-48**

**Study of intrapulse phase stability of 34-GHz magnicon for Yale project of weakly interacting sub-eV particle searches.?G.M. Kazakevich, (Yale U.) , O.K. Baker, (Yale U.) , J.L. Hirshfield, (Yale U. & Omega-P, New Haven) , Y. Jiang, (Yale U.) , M.A. LaPointe, (Yale U.) , A. Martin, (Yale U.) , S.V. Shchelkunov, (Yale U.) , P.L. Slocum, (Yale U.) , V.P. Yakovlev, (Fermilab) . FERMILAB-PUB-10-633-E, 2010. 4pp. ?Published in Nucl.Instrum.Meth.A621:238-241,2010.**

**Search for 0.1-meV axions and hidden photons using Cu resonant cavities.?P.L. Slocum, O.K. Baker, J.L. Hirshfield, Y. Jiang, G. Kazakevich, S. Kazakov, M.A. LaPointe, A. Martin, S. Shchelkunov, A. Szymkowiak, (Yale U.) . Jun 2010. 4pp. ?Prepared for 5th Patras Workshop on Axions, WIMPs and WISPs, Durham, Eng-**

**land, United Kingdom, 13-17 Jul 2009. ?Published in *Durham 2009, Patras Workshop on Axions, WIMPs and WISPs* 100-103**

**Search for Dark Matter Particles with Jefferson Lab's FEL M.D. Shinn, G.H. Biallas, . . . , O.K. Baker paper entry: WEPC29 Free Electron Laser Conference 2009, Liverpool, England**

**TeV gamma rays from distant BL Lacs and photon-paraphoton kinetic mixing. R. Anantua, O.K. Baker, (Yale U.) . 2010. 4pp. Published in Phys.Lett.B690:25-28,2010.**

**Weakly interacting sub-eV particle searches.?A. Afanasev et al. JLAB-THY-10-1221, 2010. 6pp. ?Prepared for AXIONS 2010, Gainesville, Florida, 15-17 Jan 2010. ?Published in AIP Conf.Proc.1274:163-168,2010.**

**The LIPSS search for light neutral bosons. Andrei Afanasev, (Hampton U.) , Oliver K. Baker, (Yale U.) , Kevin Beard, (MUONS Inc., Batavia) , George Biallas, (Jefferson Lab) , James Boyce, (Jefferson Lab) , Minarni Minarni, (Riau U.) , Roopchan Ramdon, (Hampton U.) , Michelle Shinn, (Jefferson Lab) , Penny Slocum, (Yale U.) . JLAB-FEL-09-1133, Jun 2010. 4pp. Prepared for 5th Patras Workshop on Axions, WIMPs and WISPs, Durham, England, United Kingdom, 13-17 Jul 2009. Published in *Durham 2009, Patras Workshop on Axions, WIMPs and WISPs* 90-93**

**LIPSS results for photons coupling to light neutral scalar bosons. Andrei Afanasev, (Hampton U.) , Oliver K. Baker, (Yale U.) , Kevin Beard, (MUONS Inc., Batavia) , George Biallas, (Jefferson Lab) , James Boyce, (Jefferson Lab) , Minarni Minarni, (Riau U.) , Roopchan Ramdon, (Hampton U.) , Michelle Shinn, (Jefferson Lab) , Penny Slocum, (Yale U.) . JLAB-FEL-08-746, Jul 2009. 4pp. Prepared for 4th Patras Workshop on Axions, WIMPs and WISPs - Training Workshop, Hamburg, Germany, 18-21 Jun 2008. Published in *Hamburg 2008, Patras Workshop on Axions, WIMPs and WISPs* 109-112**

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**New Experimental Limit on Photon Hidden-Sector Paraphoton Mixing. A. Afanasev, O.K. Baker, K.B. Beard, G. Biallas, J. Boyce, M. Minarni, R. Ramdon, M. Shinn, P. Slocum, (Hampton U. & Yale U. & MUONS Inc., Batavia & Jefferson Lab & Riau U.) . JLAB-FEL-08-742, Oct 2008. 9pp. Published in Phys.Lett.B679:317-320,2009. e-Print: arXiv:0810.4189[hep-ex]**

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