Lab report for PHYS 4311

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Abstract

We describe some experiment where we used an oscilloscope and tweezers to measure something or other. This demonstrated the equivalence of confusion with befuddlememnt and allowe us to measure $\hbar$ to a precision of ± 3 km.

1 Introduction

This piece is the introduction. It should place the experiment in some sort of general context so that the reader knows why the experiment was performed. Strive to describe the big picture. It is ok to cite other experiments[1] that may be releavanr. You can also use equations like $I = I_0 exp(-x/\mu(\lambda))$. Here, I/I_0 is the relative light intensity at wavelength λ measured at position x for light produced at $x = 0$.

Previous schemes for measuring $\mu(\lambda)$ in mineral oil have emphasized a fully manual approach. For example[2][3], light from an LED can be collimated, focussed and filtered to produce a quasi-monochromatic pencil beam which is directed along a vertical, liquid-filled tube to a photodetector at the tube's far

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end where the light intensity is measured. Manually filling/draining the tube and measuring the fluid column length is then combined with the associated light intensity to yield μ. Although straightforward to implement, such manual procedures tend to be both time consuming and susceptible to systematic error from the potentially large number of human interactions required for extensive sampling. The procedure described in this article substitutes an electronic technique for the manual filling/draining and fluid column measurement and was developed for the electron neutrino appearance experiment NOνA[4] at Fermilab as part of a suite of testing techniques for ensuring the quality of the experiment's 16 million liters of liquid scintillator.

2 Two column spectrophotometer

Our technique relies on a two column spectrophotometer, with both vertical columns filled with the mineral oil to be tested and supplied in parallel by a vertically adjustable oil reservoir. The "optical column" has filtered and focussed light directed along its length to a photomultupier (PMT) at its far end. The parallel plumbed "capacitive" column has its capacitance, related to the length of it filled with oil, measured electronically. Detected light intensity as a function of fluid column length yields the oil's $\mu(\lambda)$.

The structure of the optical column is conventional. A blue LED, pinhole, converging lens and narrow bandpass filter are positioned axially at the top of the 5 cm diameter aluminum alloy tube. The filtered LED light is collimated and focussed to produce a $\sim 3\,\text{cm}$ diameter spot size in a horizontal plane at the end of the tube 1.2 meters away. The tube bottom is sealed with a borosilicate window, against which a 51 mm diameter PMT is placed. The PMT photo-

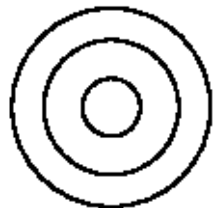

Fig. 1. Schematic of two-column spectrophotometer, showing the reservoir, optics column and capacitive column.

cathode is biased at negative high voltage and the photocurrent is readout in DC mode by a simple op-amp circuit configured as a transimpedance amplifier with a 600 kΩ resistor in the feedback loop. The optical tube is sealed against light and a stainleess steel valve installed at the tube bottom aids oil draining when changing oil samples.

The aluminum alloy capacitor tube is a pair of 1.0 m long concentric tubes with annular radii 1.5 cm and 2.5 cm. It is open to the atmosphere at the top but sealed at the bottom with a PVC disk. Oil is admitted to the volume between the individual tubes through a fitting attached to a 1 cm diameter hole drilled in the outer diameter tube. Opaque polysomething tubing of diameter 1 cm connects the capacitor tube to both the optics tube and the oil reservoir. See Figure 1 for a schematic of the arrangement.

A 4 liter oil reservoir supplies both the optics and capacitor tube through a “tee” connection so that all three can be placed in hydrostatic equilibrium with one another. The reservoir is a attached to stage driven by a stepper motor, permitting the vertical level of the fluid in the optics and capacitor tube to vary by ~ 80 cm. The nominal step size d of the motor controller in combination with the stepper lead screw is ~ 0.1 mm.

3 Math equations

You may need to write an equation, or two. You already have seen how to write one inside a paragraph: you just type the latex math command sandwiched between $ signs: $\int_0^\infty e^{-x} = 1$. You write an equation all by its lonesome and **without** equation numbers:

$$\mathrm{e}^{\mathrm{i}\pi} + 1 = 0.$$

or with equation numnbers:

$$\mathrm{e}^{\mathrm{i}\pi} + 1 = 0 \tag{1}$$

You can now refer to formula 1 in your text. The command

```
\label{eq:euler}
```

in the source code just attaches a label to the formaula that allows you to reference it. this is a handy trick.

4 Conclusion

Finish what you start.

References

[1] Borexino, Daya bay, Double Chooz, miniBOONE, NOνA.

[2] J.L. Raaf et al., *IEEE Trans. Nucl. Sci.* 49 (2002) 957.

[3] J.P. Petrakis et al., *Nucl. Instr. Meth.* A 268 (1988) 256.

[4] J.H. Christ et al., *Some Journal* 123 (2007) 1.