Evaluation of Polarization Dependence in Nonlinear Optical Detectors

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Introduction

❖All-optical networks, which employ nonlinear effects, are far simpler and faster in principle than electronically processed networks

Problem: We can not replace electronic processing with all- optical processing because the polarization state of light varies unpredictably in all-optical networks.

Solution: Find a broadband nonlinear process that is insensitive to the input polarization state.

Objective:

•Study the nonlinear process Two-Photon Absorption (TPA)
• Investigate factors that affect TPA
• Determine if the photomultiplier tube (PMT) is an attractive candidate for observing TPA

TPA

- A nonlinear-effect in which the absorption of two photons produces a single electron-hole pair.
- Generates a photocurrent that is proportional to the square of the input optical power

Measuring TPA

•PMT Observed pure TPA
•Power Range:

$3\text{ mW} < P < 36\text{ mW}$

•Output Voltage Range:

$3\text{mV} < V_{TPA} < 470\text{ mV}$

Conclusion: High Output Voltage

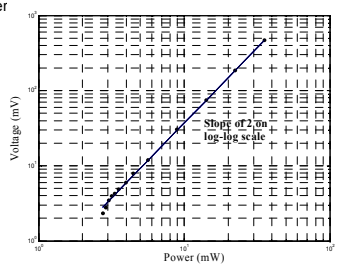


Fig 2: Output Voltage vs. Input Power

Polarization Dependence

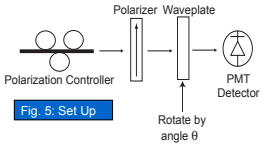


Fig. 5: Set Up

•Vary input polarization through rotating wave plate by angle θ

•θ is the angle between the input polarization and the wave plate's fast axis.

•Half Wave plate ⇨ Linearly Polarized Light

•Quarter Wave Plate ⇨ Elliptically Polarized Light

Linearly Polarized Light

•Rotate half wave plate by angle θ

•Rotation changes the orientation of linearly polarized light by an angle of 2θ

Conclusion: Constant curve suggests the PMT's photocathode exhibits isotropic properties.

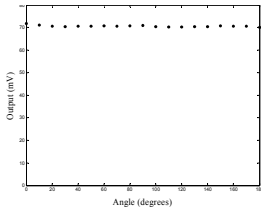
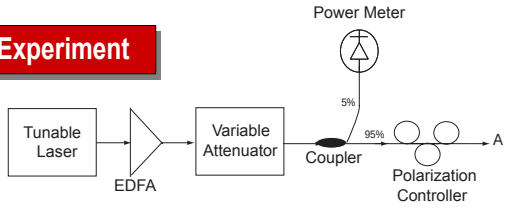


Fig. 6: Output vs. Half Wave Plate Rotation angle

Experiment



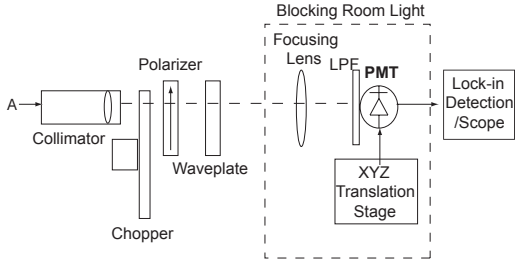


Fig. 1: Schematic Set up for observing TPA process

Wavelength Dependence

• Varied the input wavelength:

$1535 \le \lambda \le 1565$

•Limited only by bandwidth of EDFA
•Slight dependence to wavelength
•No Oscillations

Conclusion: Broad bandwidth Response

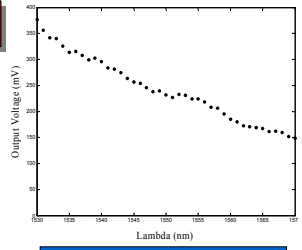


Fig. 3: Output Voltage vs. Lambda

Spot Size Sensitivity

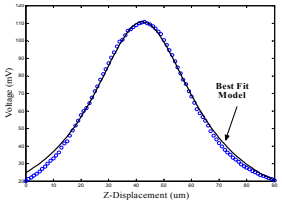


Fig. 4: Output Voltage vs. Z-Displacement

•TPA photocurrent depends on the spot size of the beam of light.

•As spot-size decreases, the photocurrent increases by a factor of $\frac{1}{w^2}$

Conclusion: From best fit model, we determine the absorbing region of PMT's photocathode is very thin.

Elliptically Polarized Light

•Rotate Quarter wave plate by angle θ

•Rotation converts an input polarization from circular to linear

•Minimum TPA when polarization is circular

•Maximum TPA when polarization is linear

Conclusion: Output TPA increases by a factor of 10/9 as input polarization changes from circular to linear

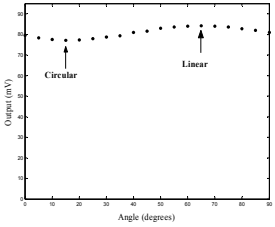


Fig. 7: Output vs. Quarter Wave Plate Rotation Angle

Summary

The PMT is an attractive candidate for TPA experiments for the following reasons:

- High Output Voltage
- Broadband Response
- Thin Absorbing Region
- Low Polarization Sensitivity

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