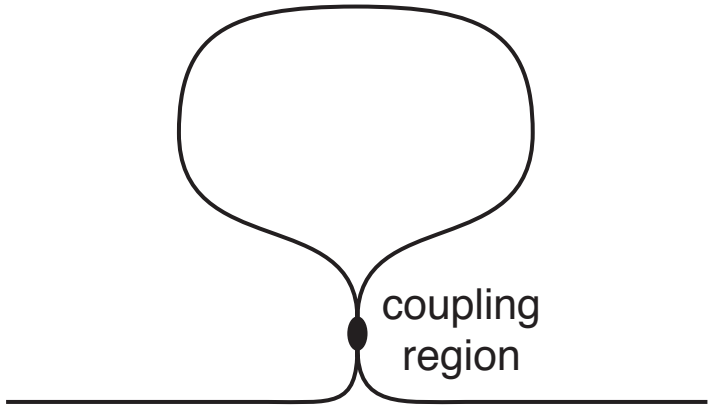
# Silica Nanowires Part IV: Applications

RS Seminar on Science and Technology of Silica Nanowires
Kavli Institute of the Royal Society
Milton Keynes, United Kingdom, 9 November 2012

# Optical logic gates

## nanowire Sagnac interferometer



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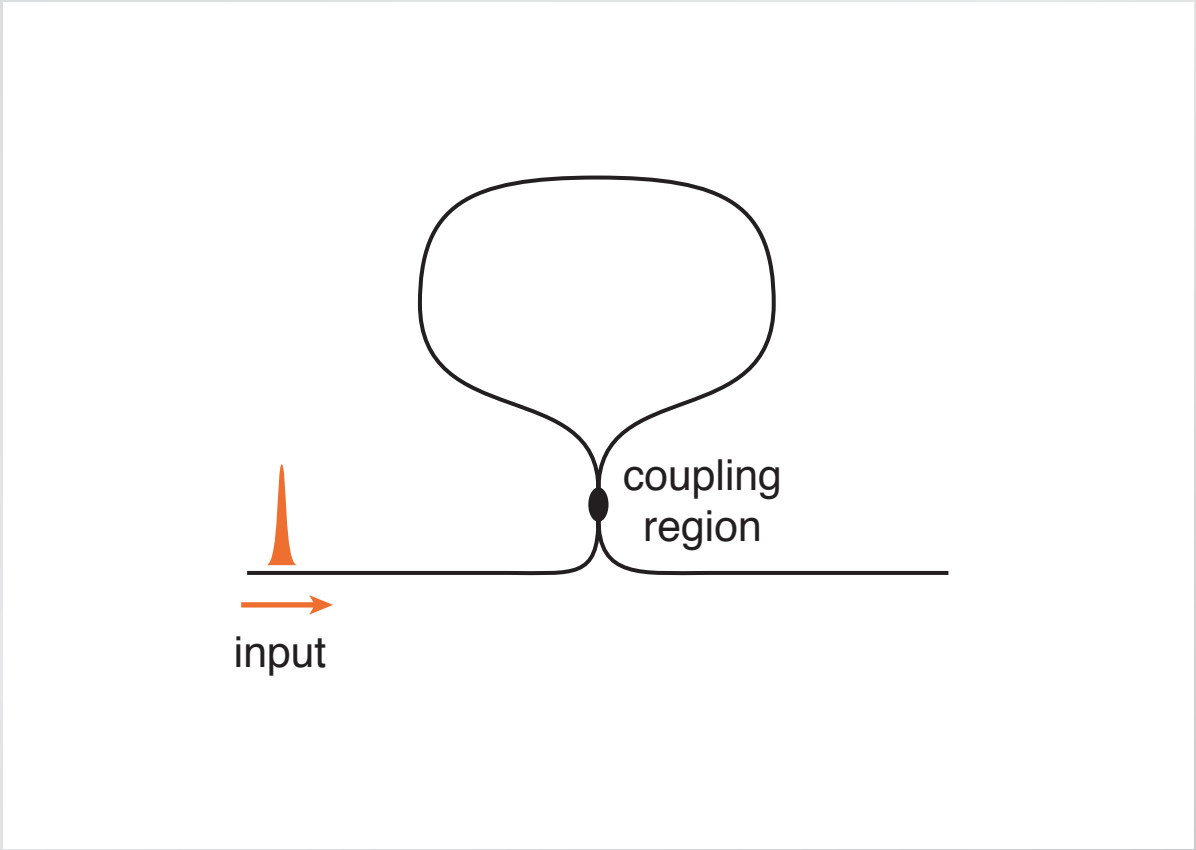

# Optical logic gates

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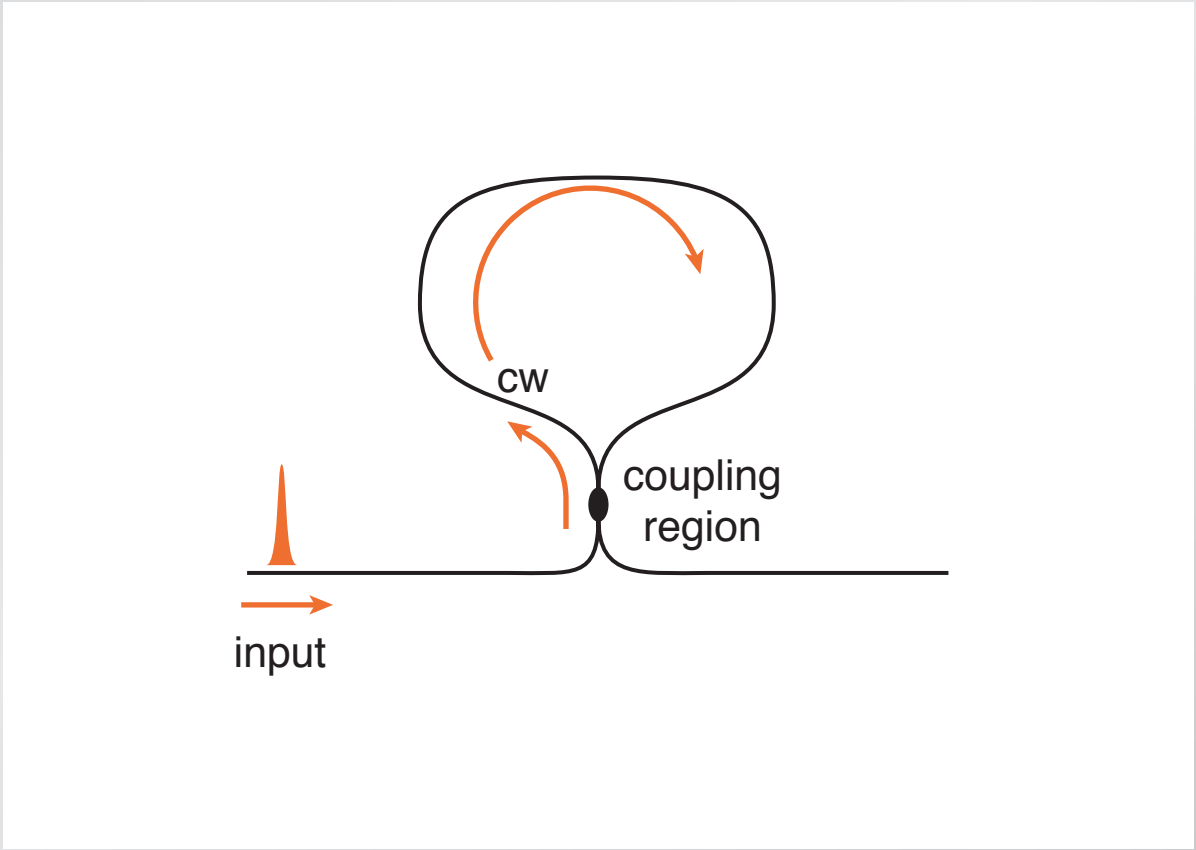

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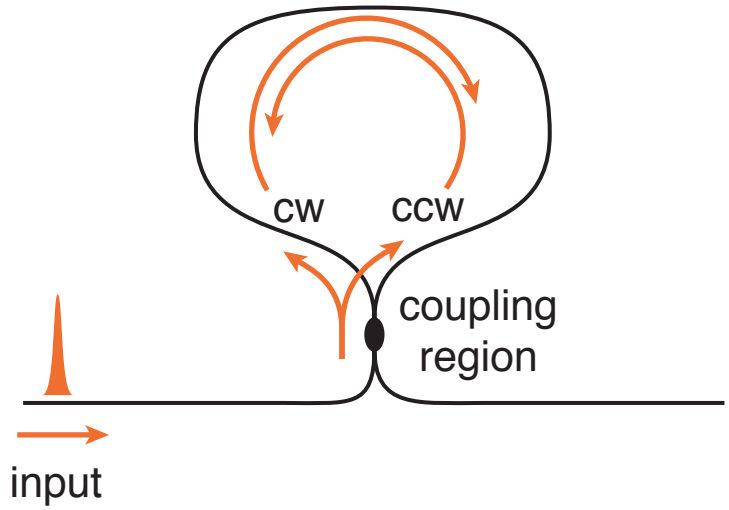

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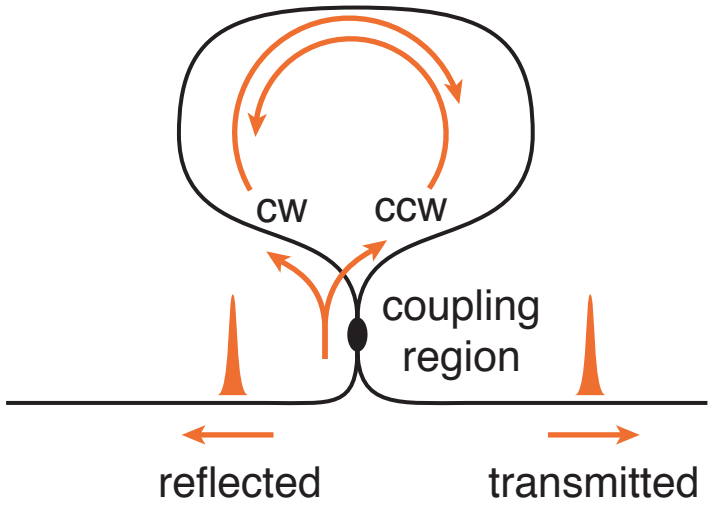
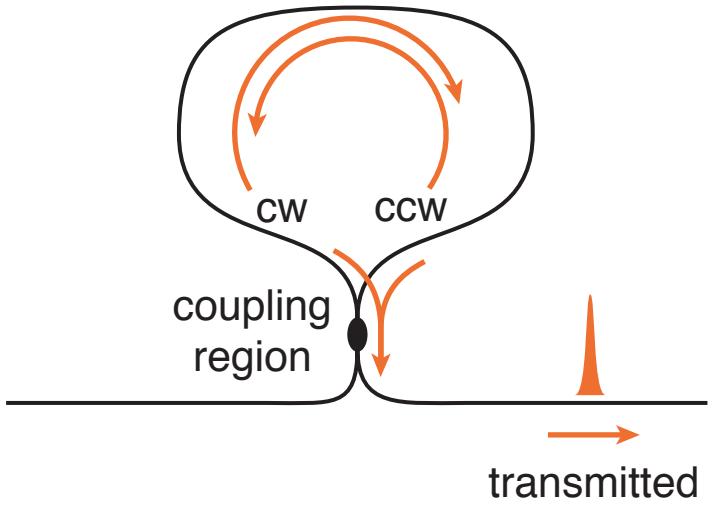


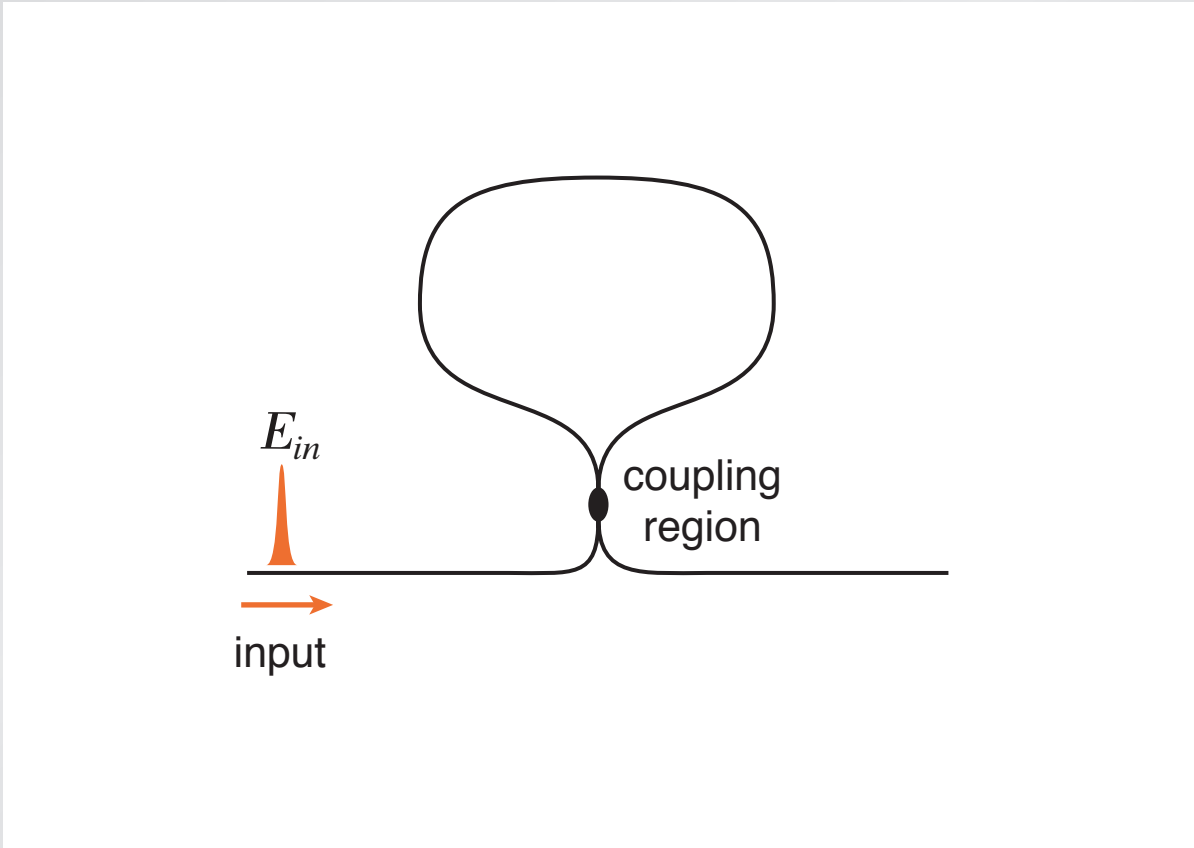
# Optical logic gates

**output = transmitted cw + ccw power**



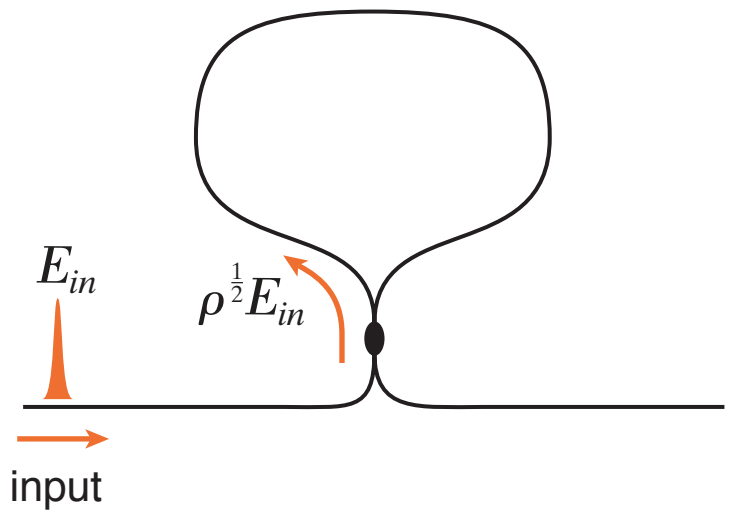
# Optical logic gates

**input electric field amplitude $E_{in}$**



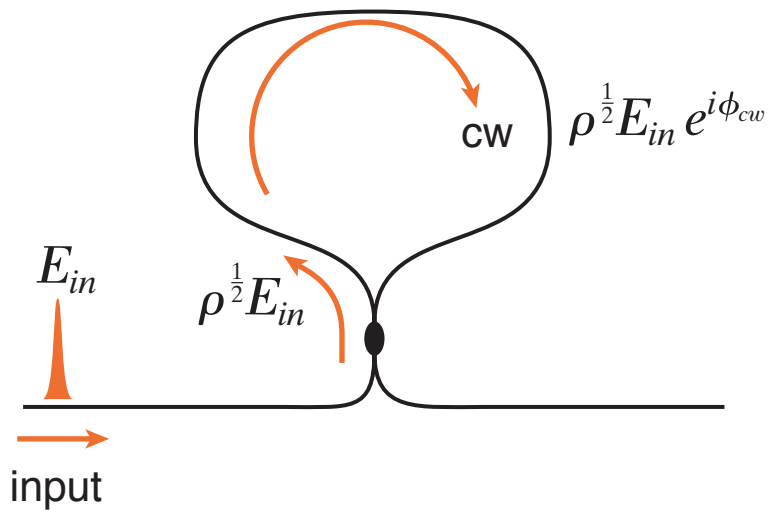
# Optical logic gates

**coupling parameter: ρ**



# Optical logic gates

phase accumulation over path length of loop $L$



# Optical logic gates

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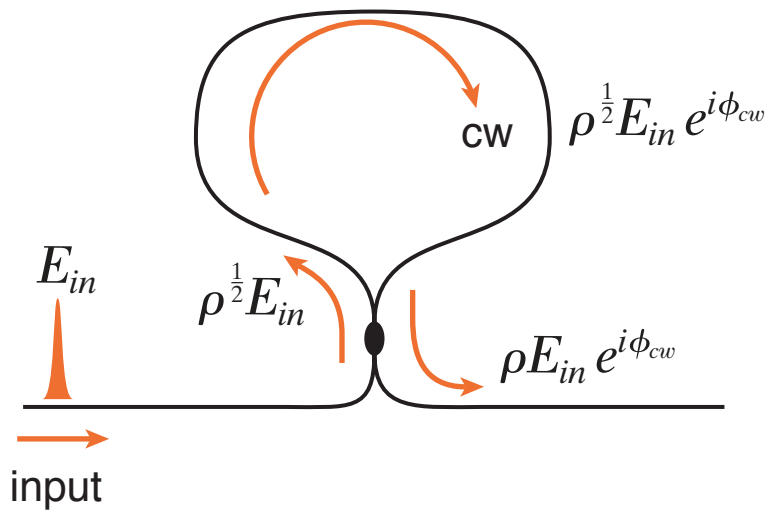
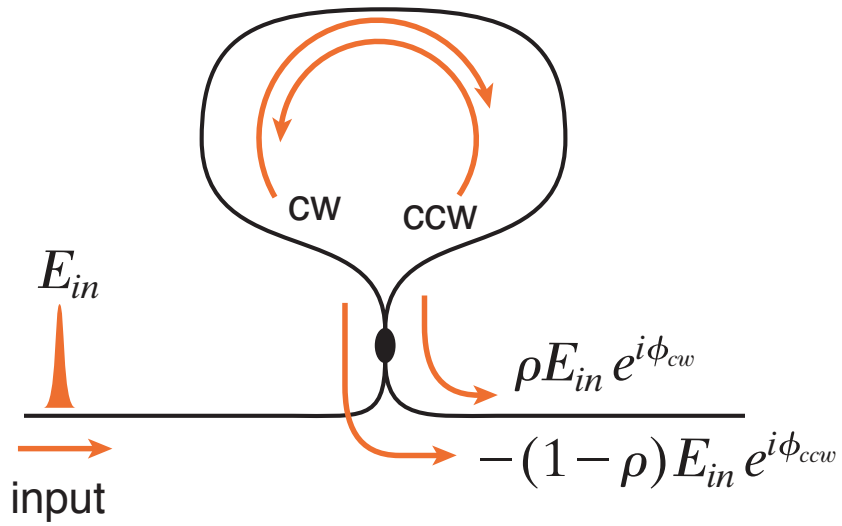


# Optical logic gates

**output is sum of transmitted cw and ccw**



# Manipulating light at the nanoscale

**accumulated phase:**

$$\phi = k_o n$$

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$$n = n_o + n_2 I = n_o + n_2 \frac{P_i}{A_{eff}}$$

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**nonlinear parameter:**

$$\gamma = n_2 \frac{k_o}{A_{eff}}$$

# Manipulating light at the nanoscale

**power-dependent output:**

$$\frac{E_{out}^2}{E_{in}^2} = 1 - 2\rho(1 - \rho)\{1 + \cos[(1 - 2\rho)\gamma P_o L]\}$$

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**for 50-50 coupler:**

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**for 50-50 coupler:**

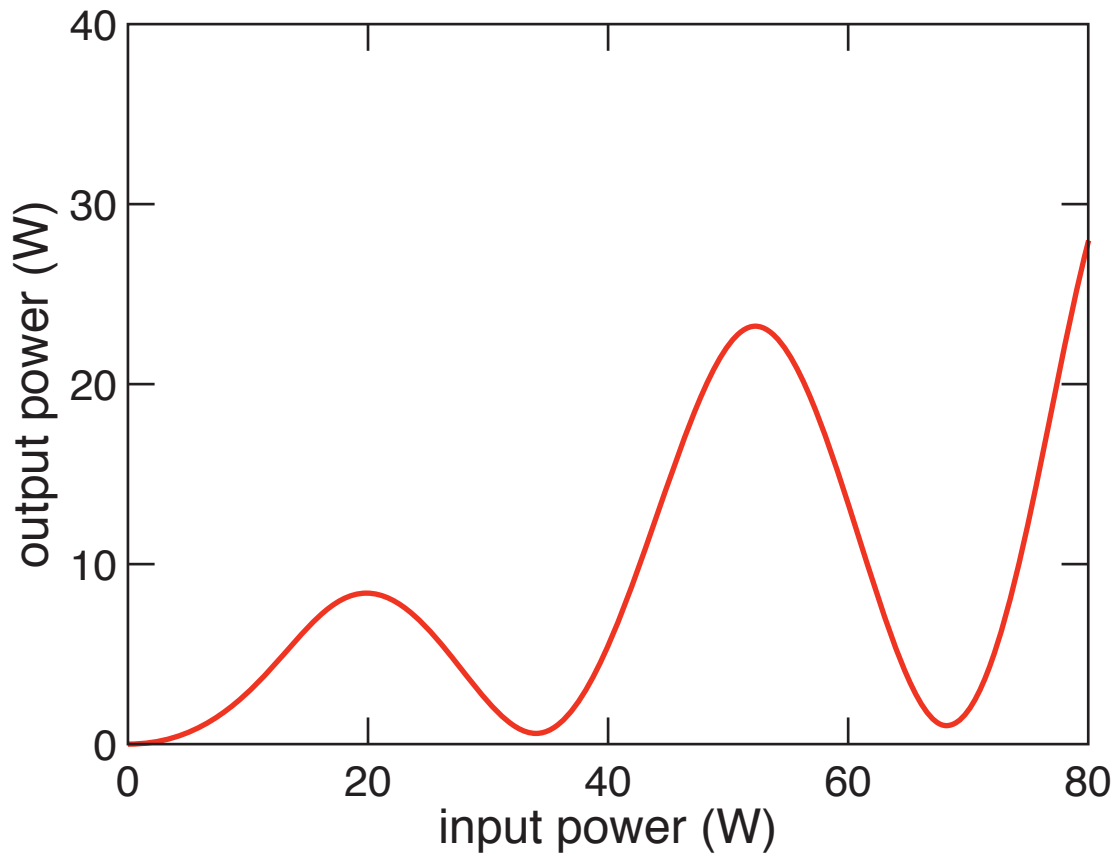
$$\rho = 0.5$$

**no transmission:**

$$\frac{E_{out}^2}{E_{in}^2} = 0$$

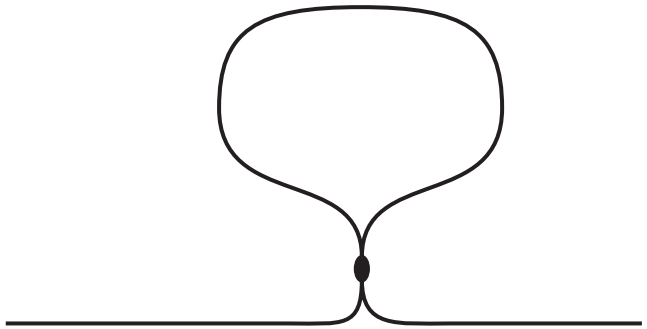
# Optical logic gates

**when $\rho \neq 0.5$:**



# Optical logic gates

## nonlinear nanogate



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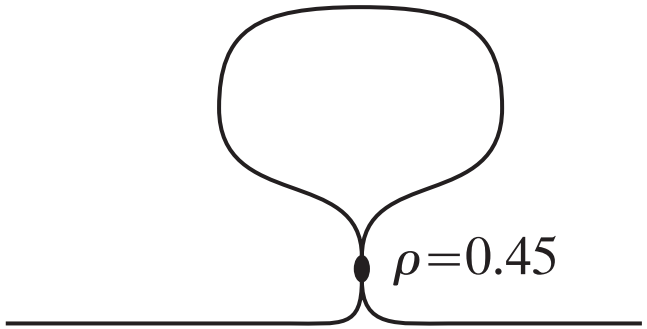


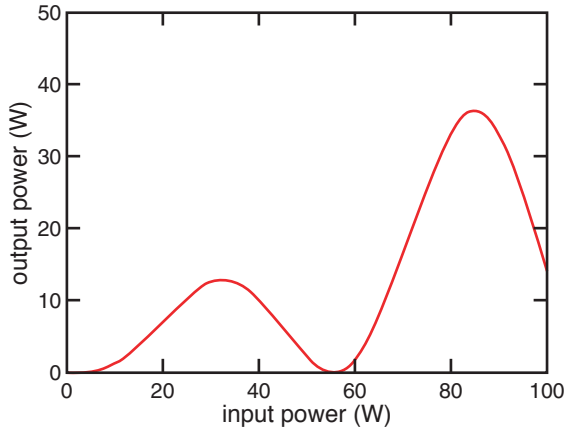

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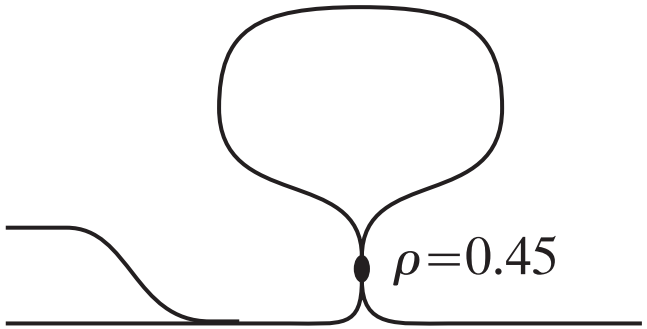


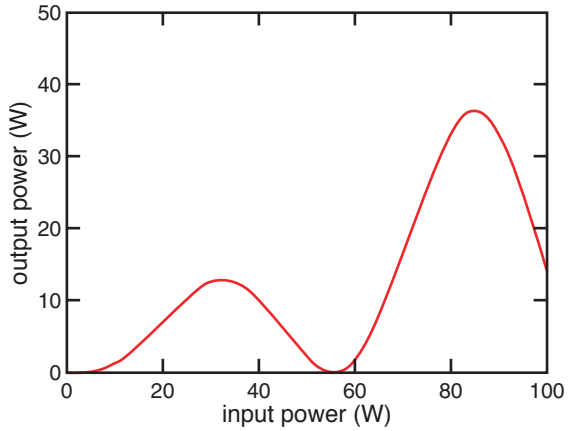

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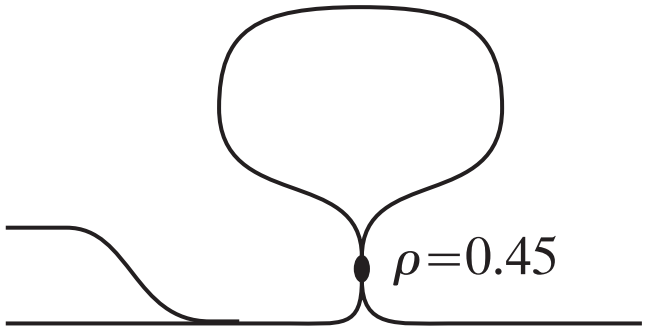


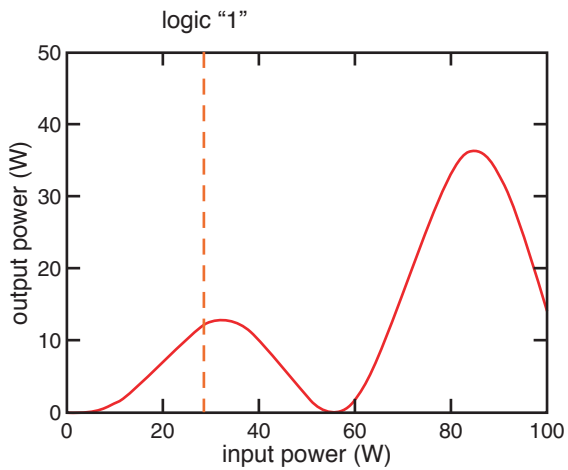

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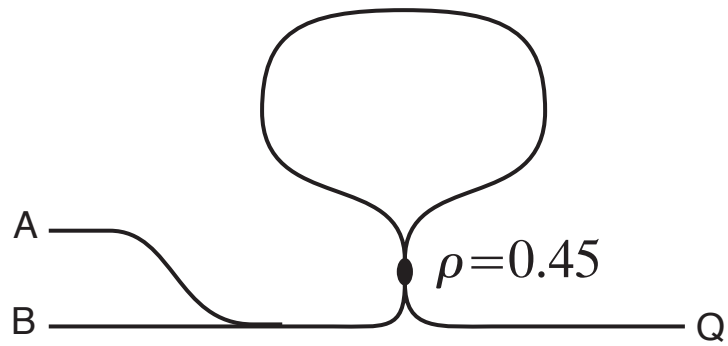


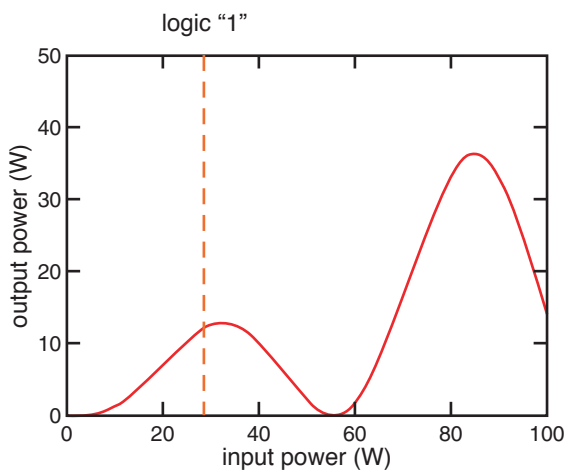


| A | B | Q |
|---|---|---|
| 0 | 0 | 0 |

# Optical logic gates

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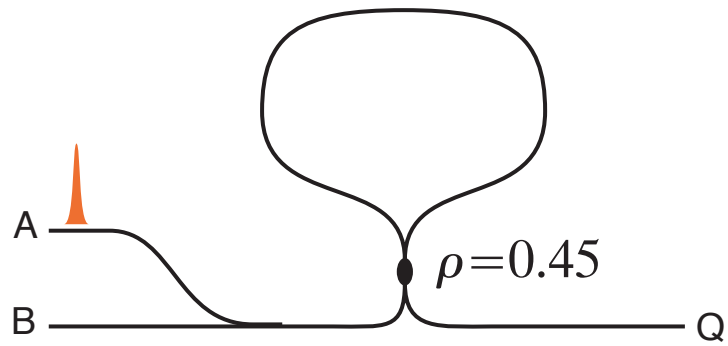


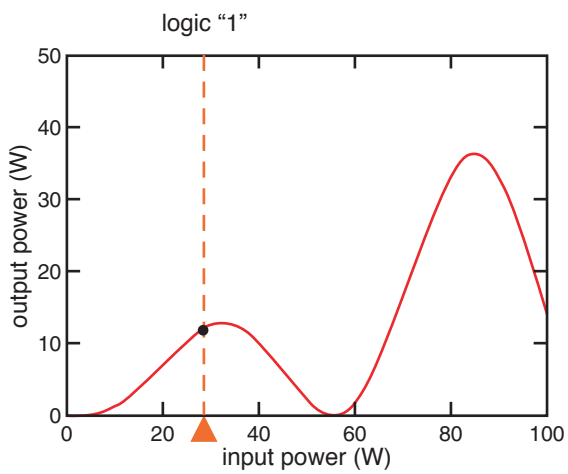


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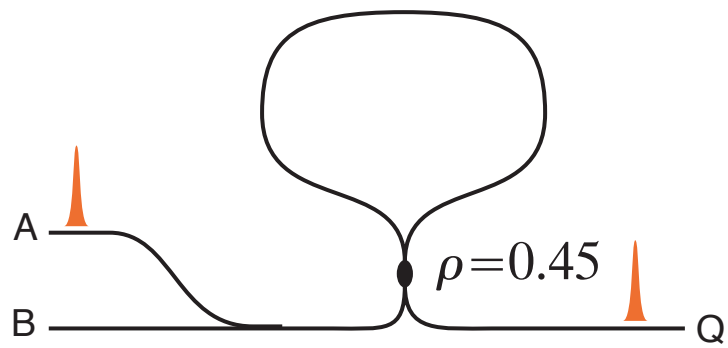


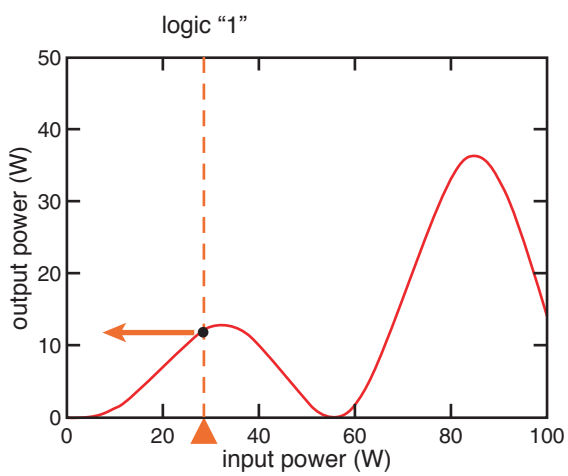


| A | B | Q |
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| 0 | 0 | 0 |
| 1 | 0 | 1 |

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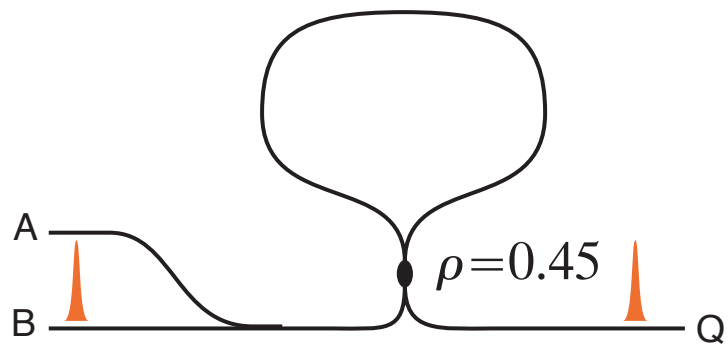


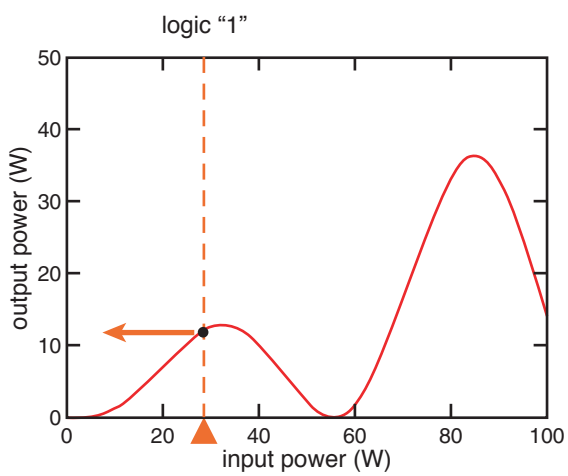


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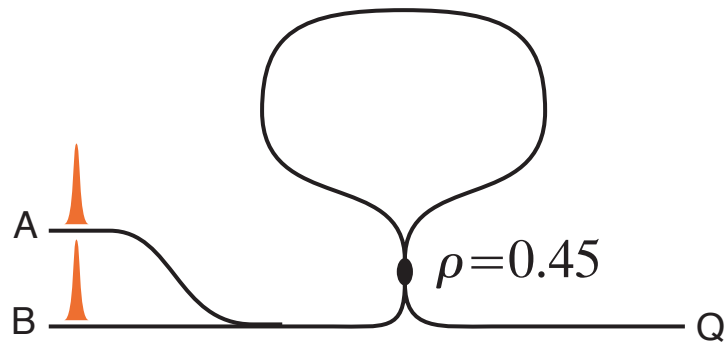


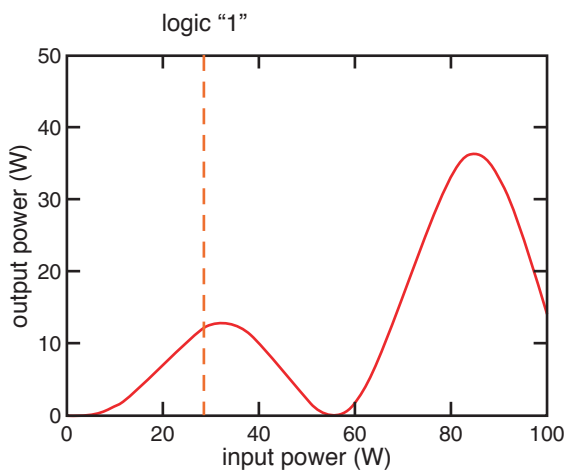


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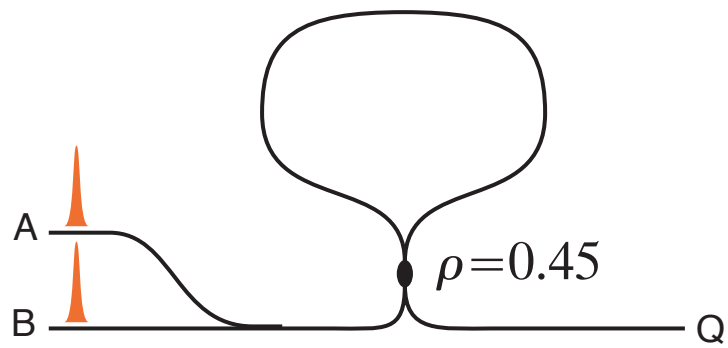


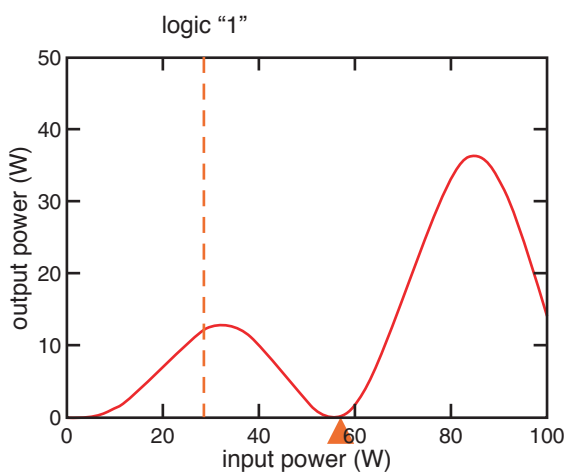


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# Optical logic gates

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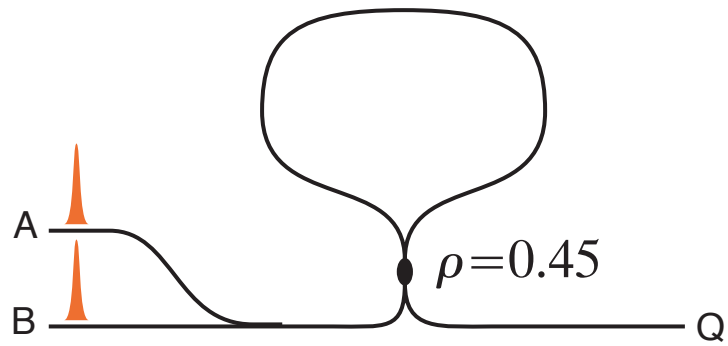


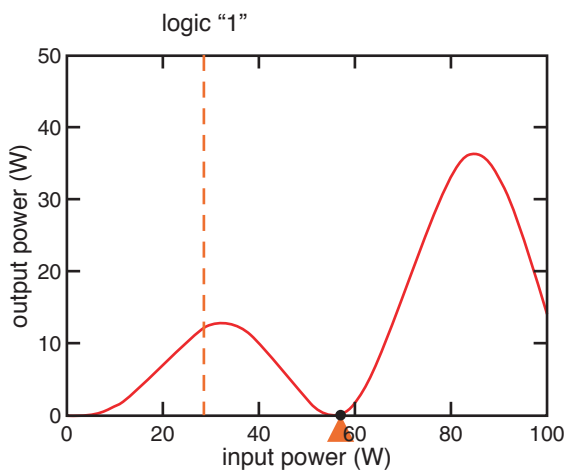


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# Optical logic gates

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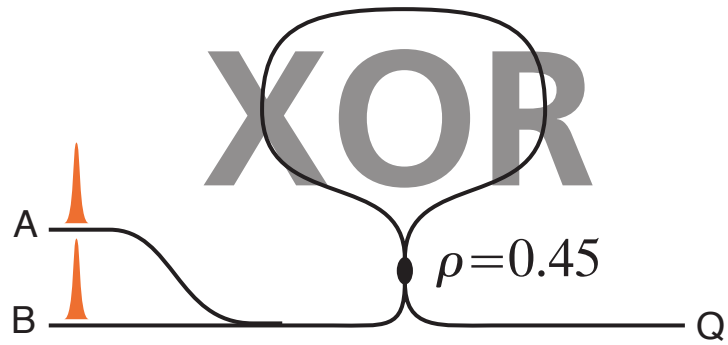


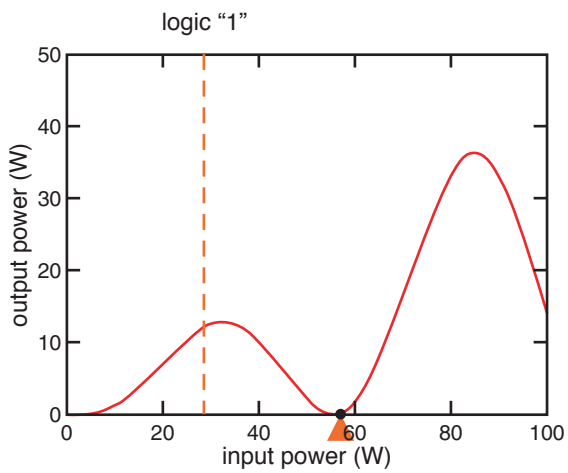


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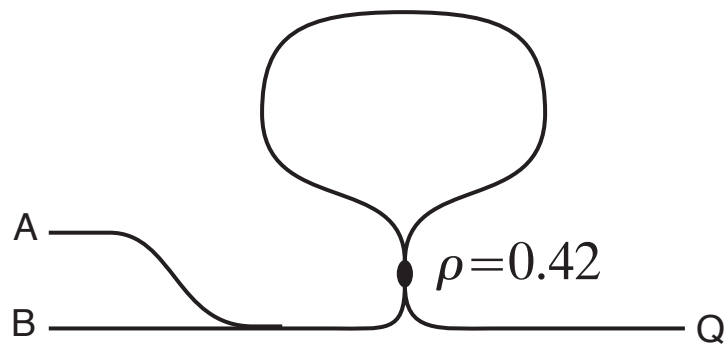


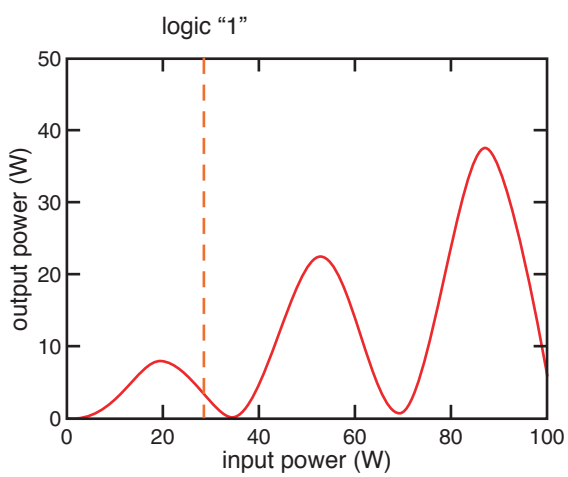


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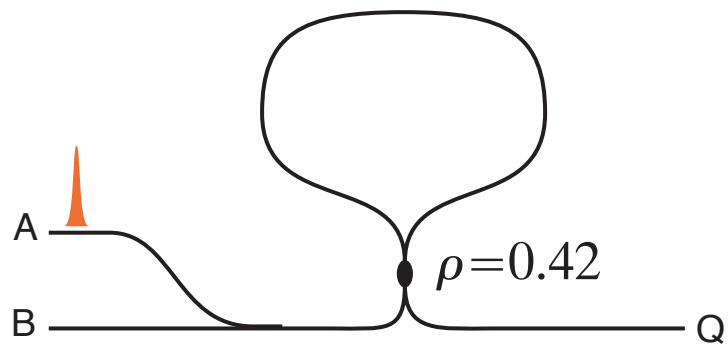


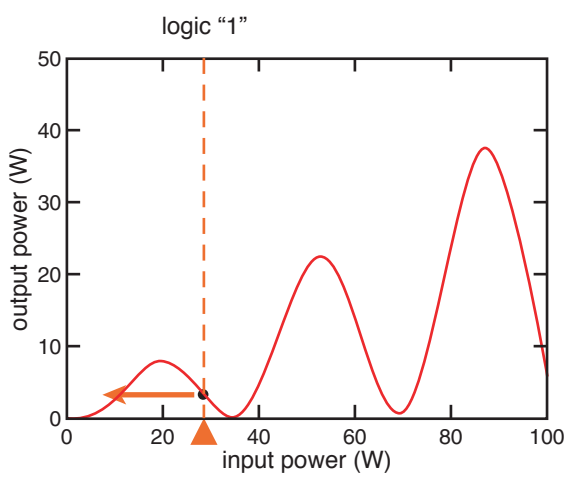


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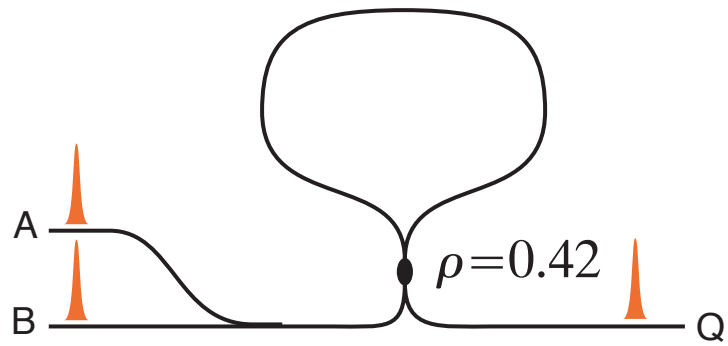


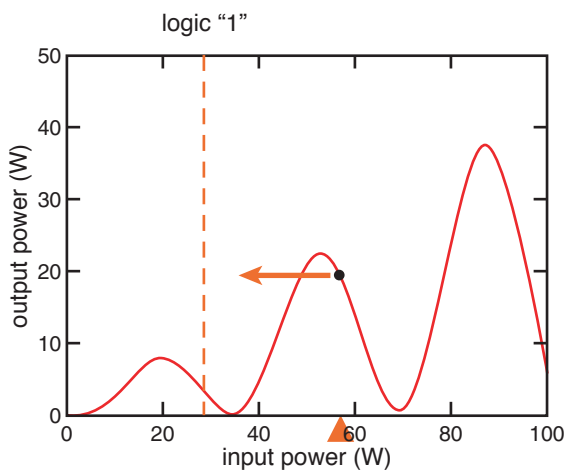


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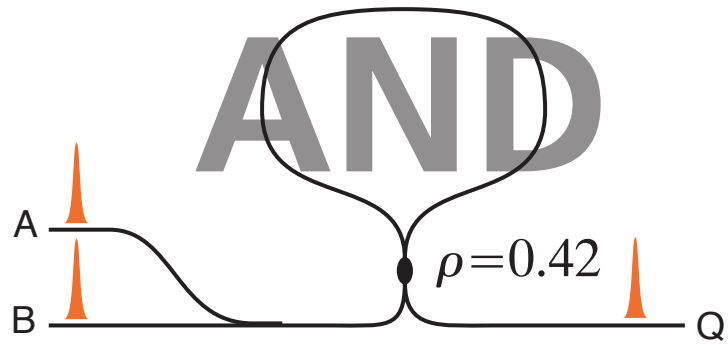


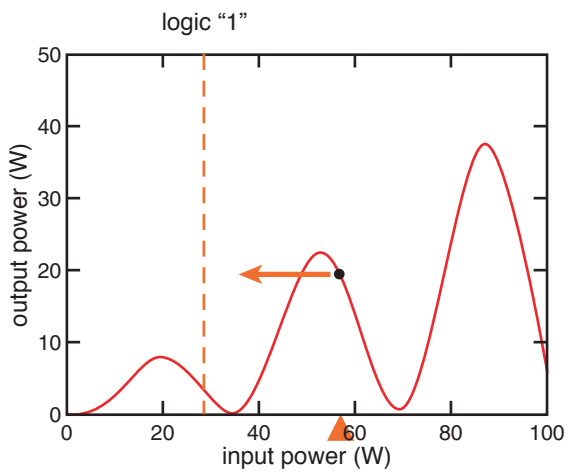


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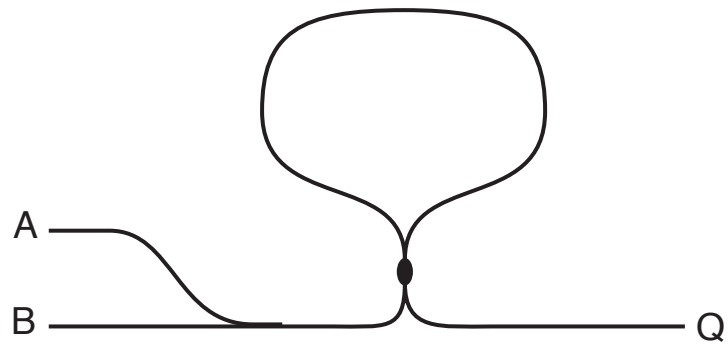
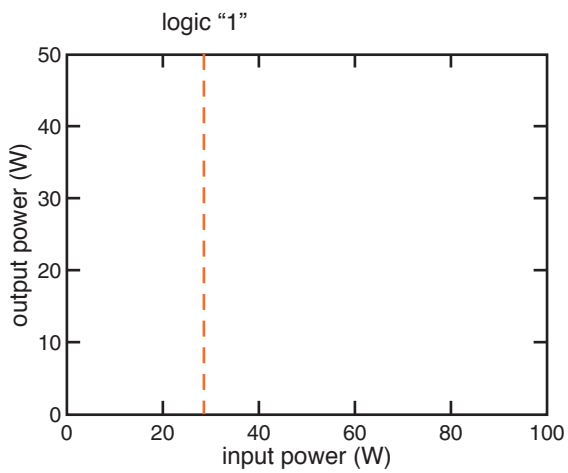
# Optical logic gates

## for NAND gate need ouput with no input

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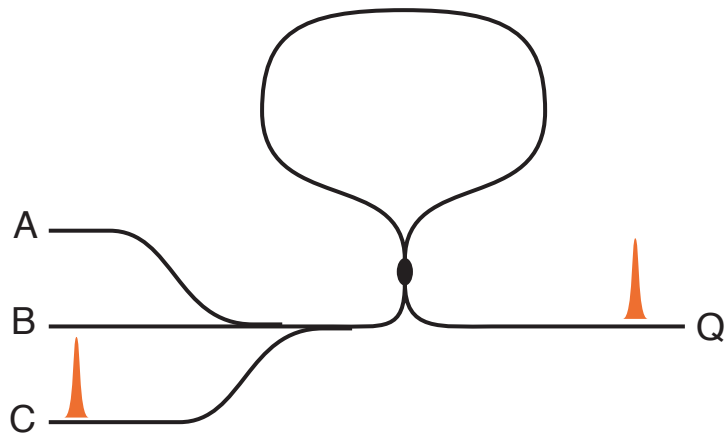


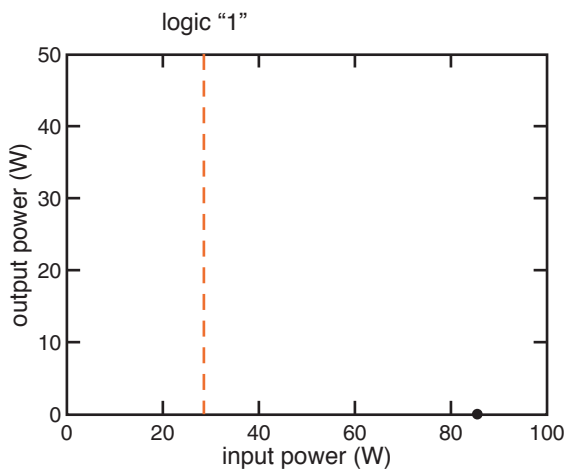


| A | B | Q |
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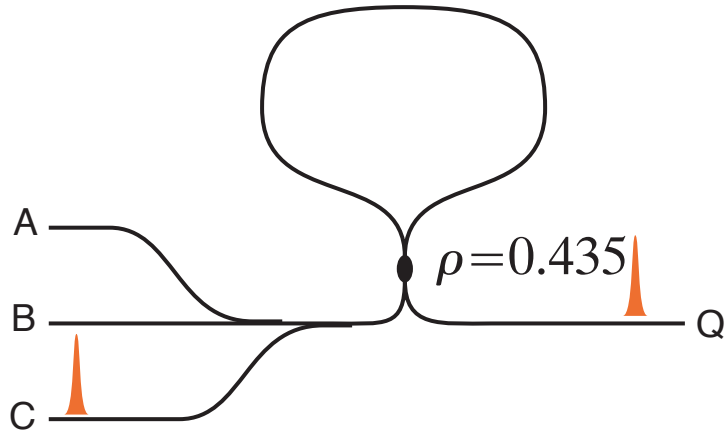
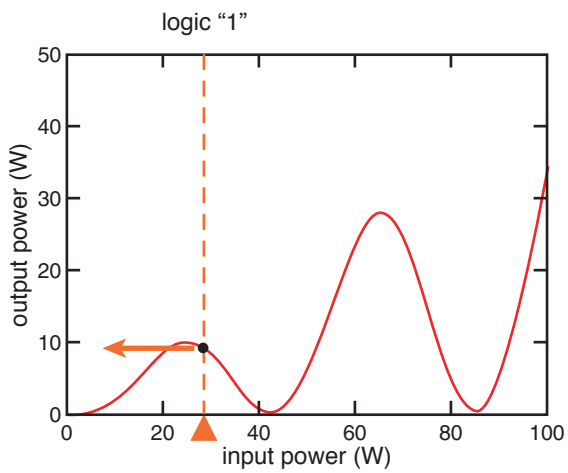
# Optical logic gates

## for NAND gate need ouput with no input

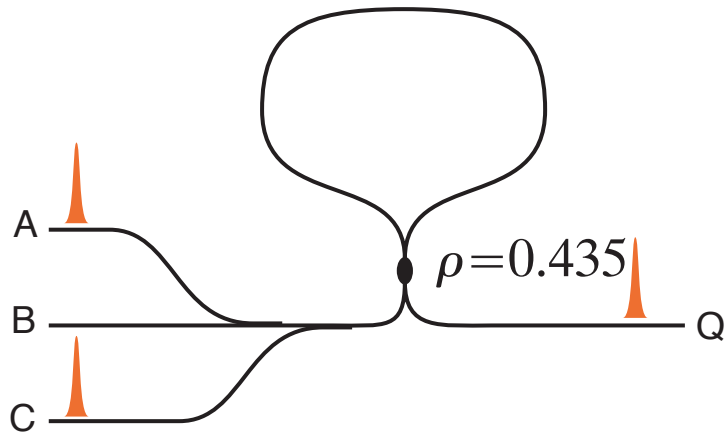


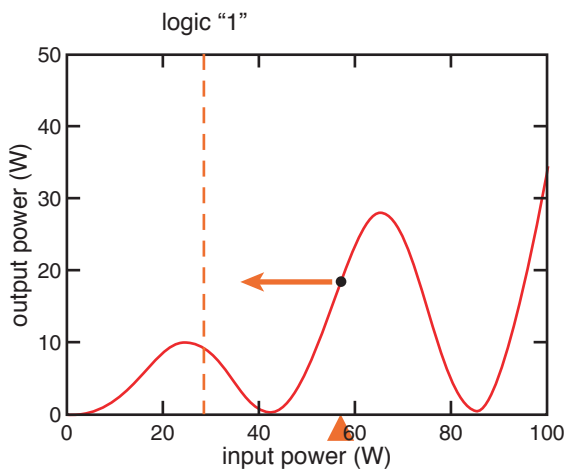




| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |

# Optical logic gates

## universal NAND gate

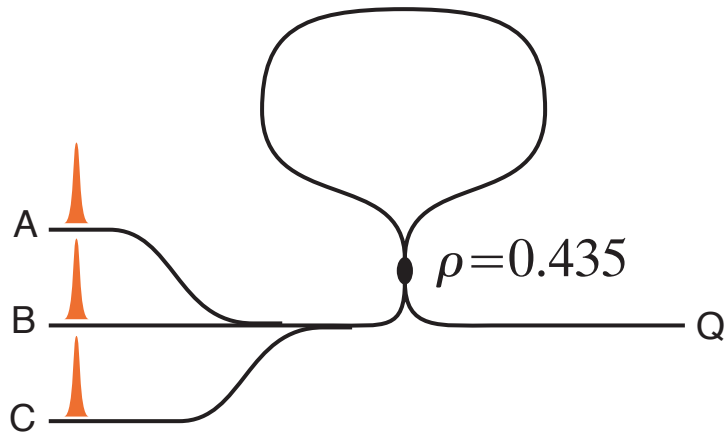


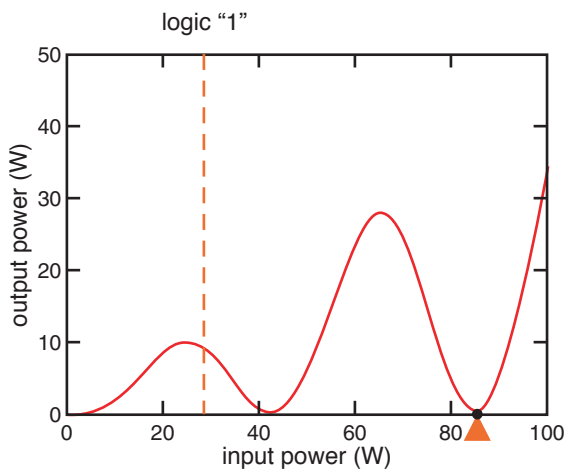




| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |

# Optical logic gates

## universal NAND gate

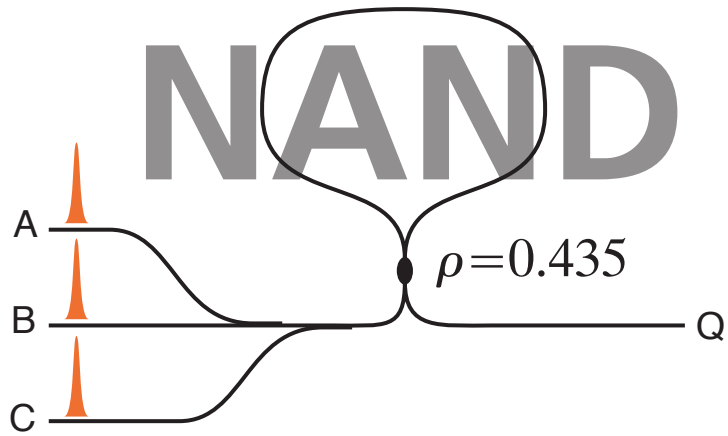


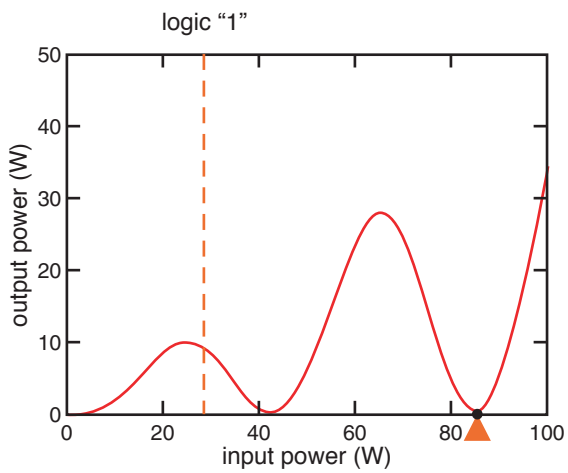




| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 1 | 0 |

# Optical logic gates

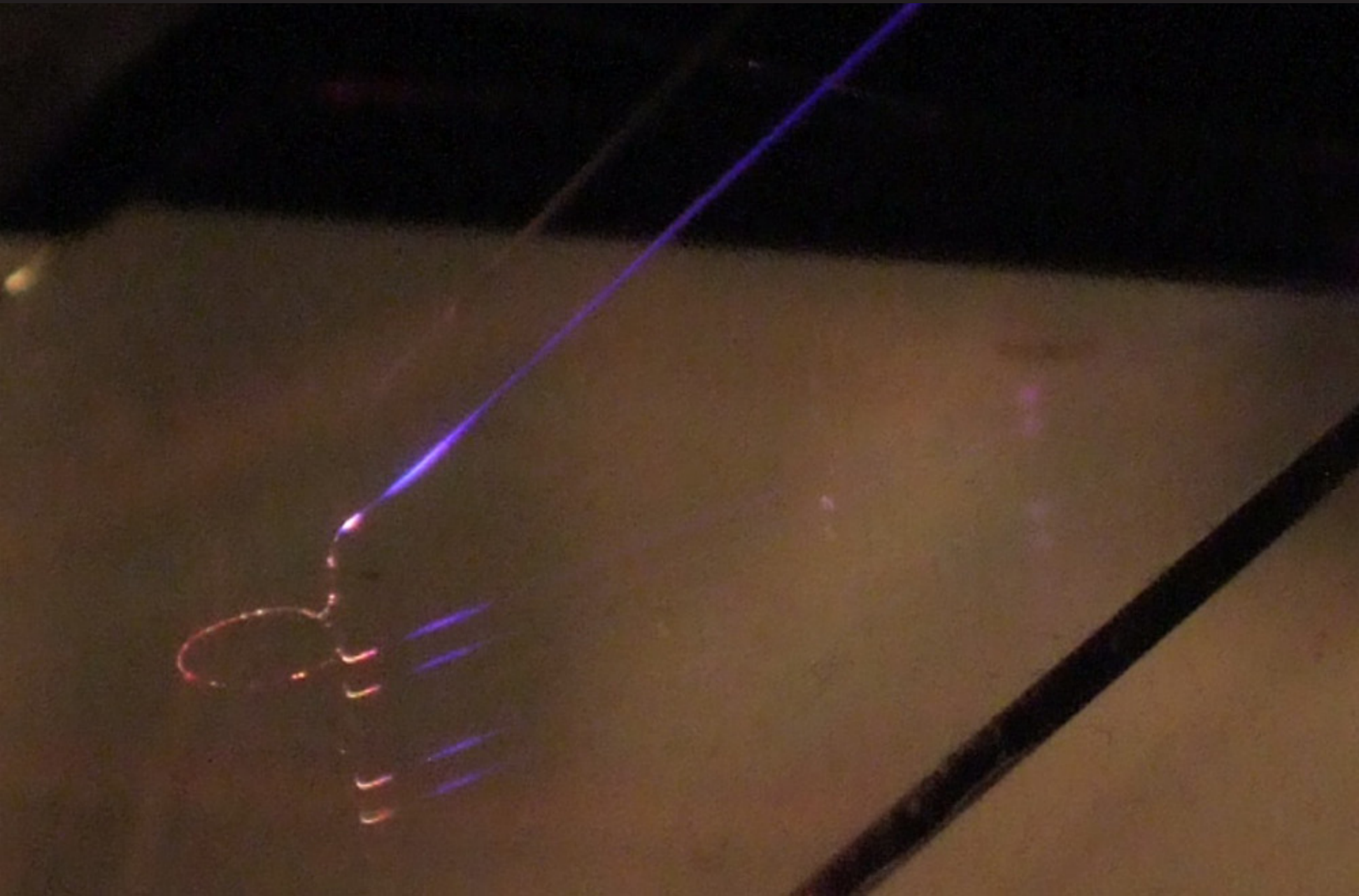
## universal NAND gate



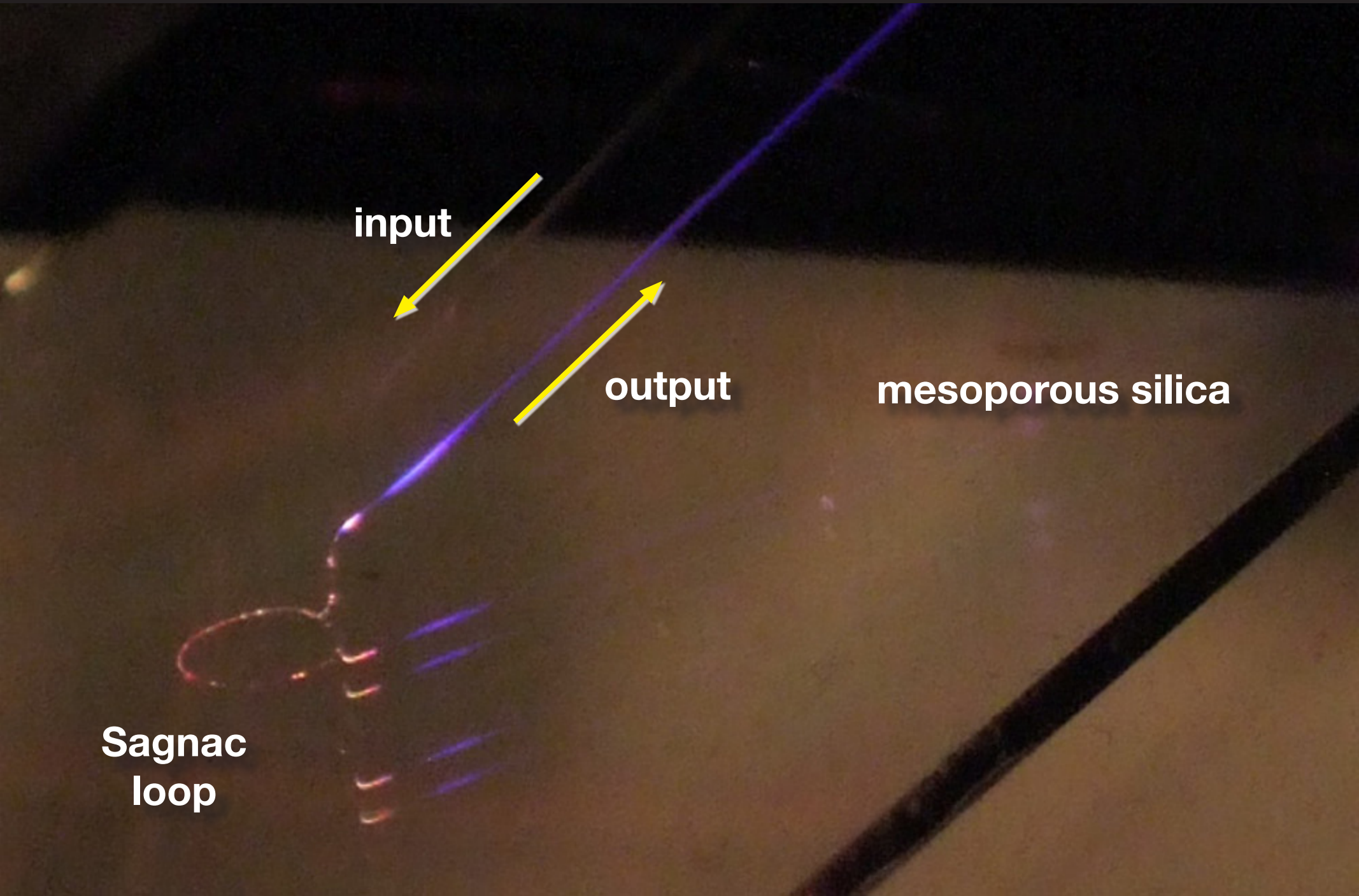

| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 1 | 0 |

# Optical logic gates



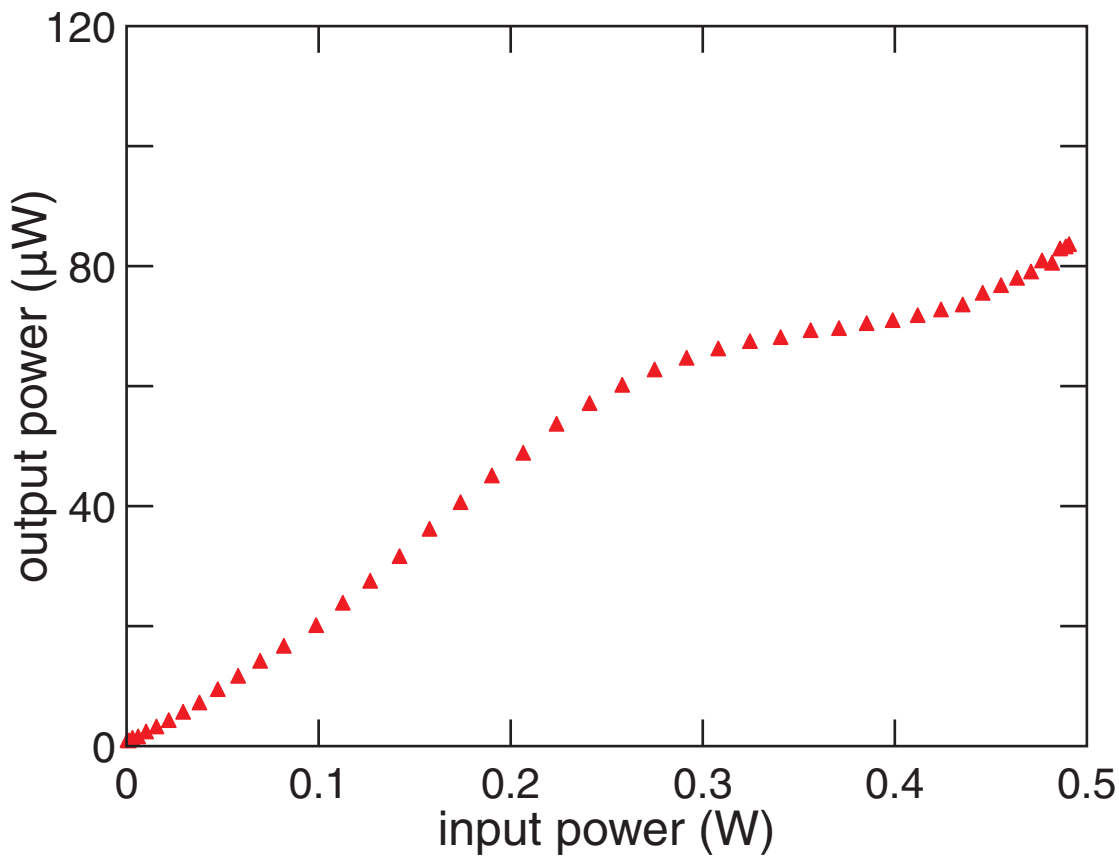
# Optical logic gates

# Optical logic gates



# Optical logic gates

## very preliminary data

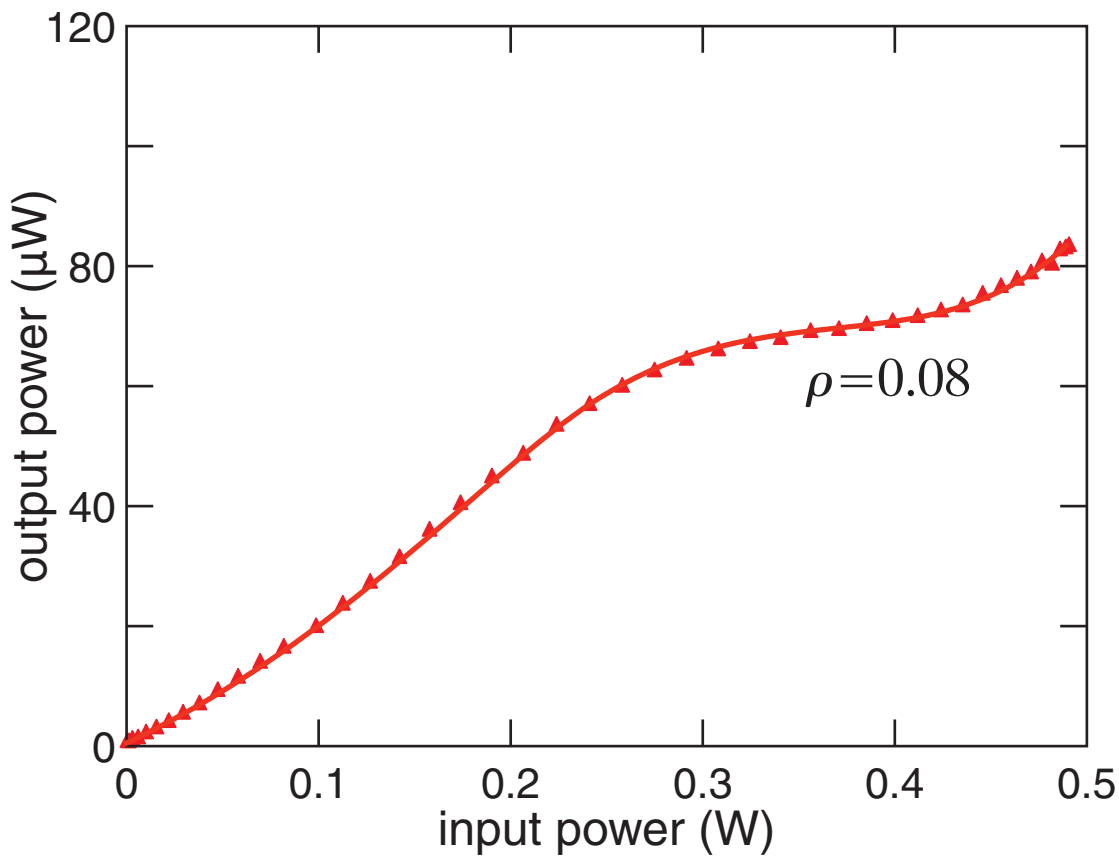


# Optical logic gates

**light-by-light modulation!**

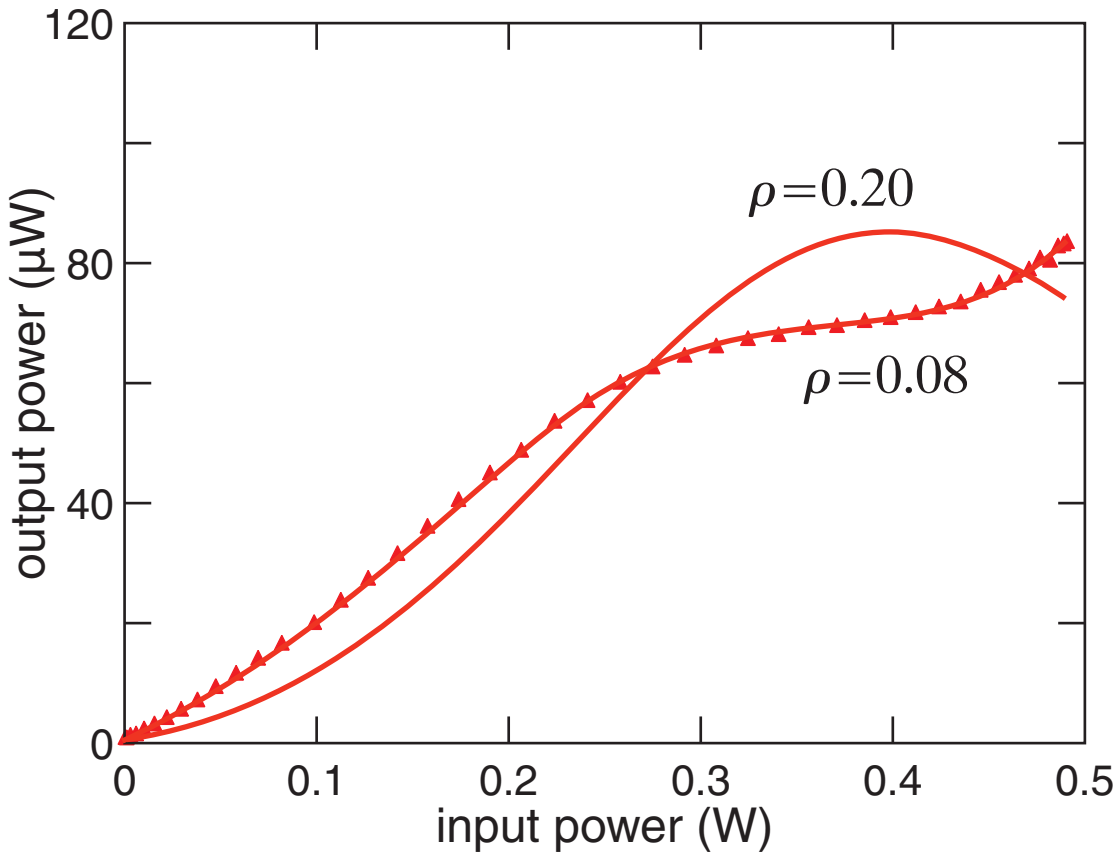
# Optical logic gates

## very preliminary data

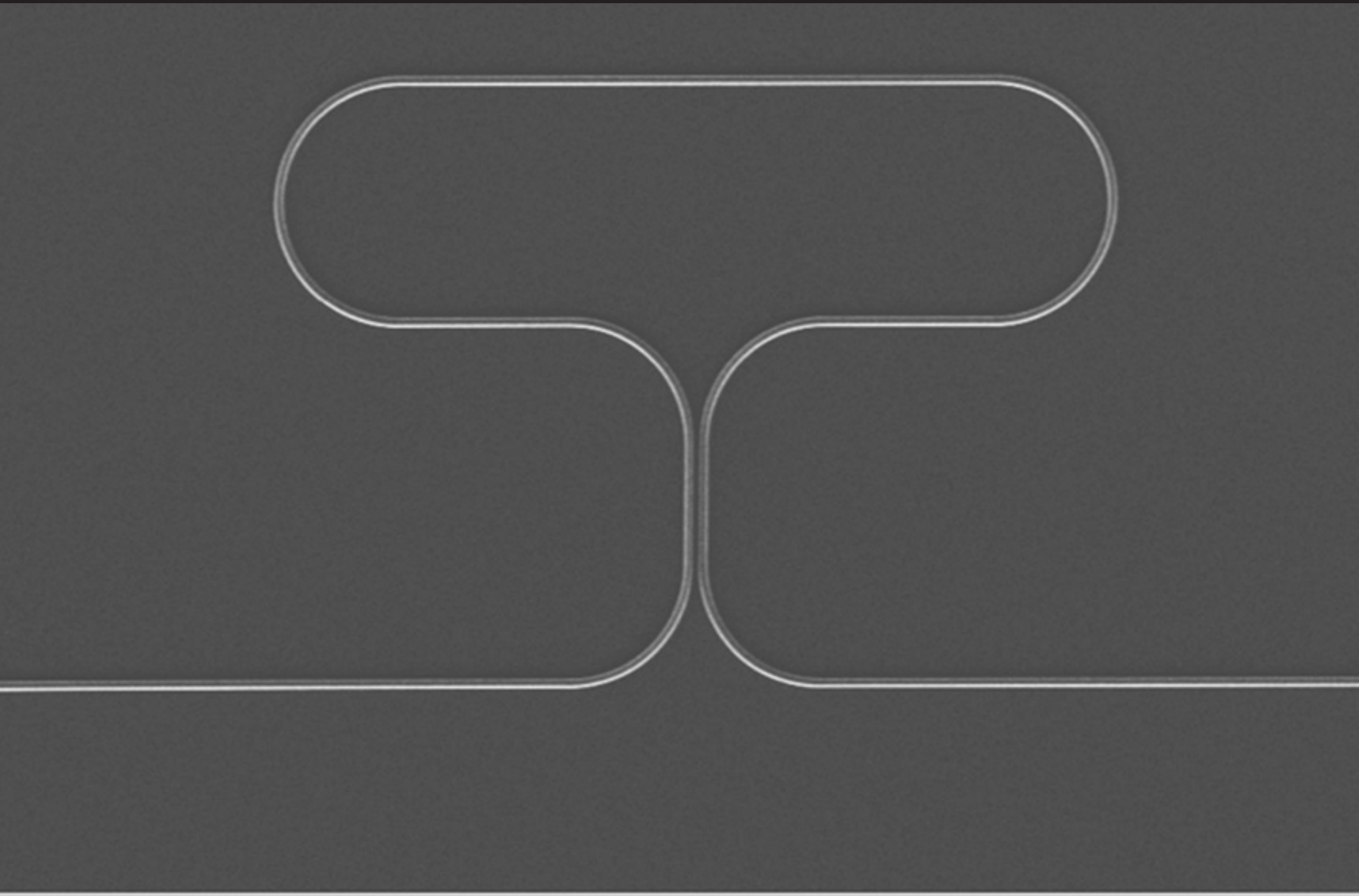


# Optical logic gates

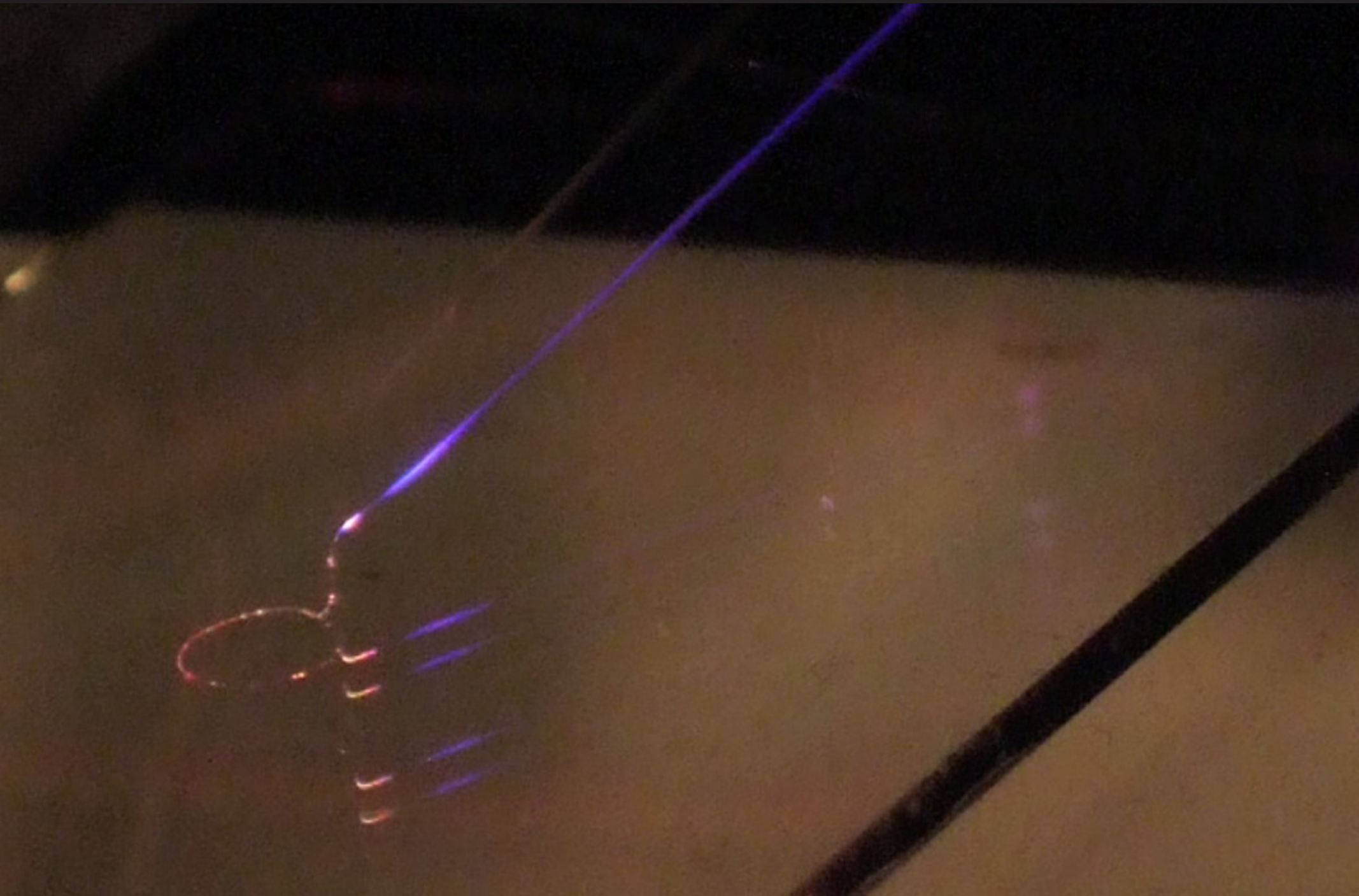
## very preliminary data



# Optical logic gates



# Summary



# Summary

- several nanodevices demonstrated
- large $\gamma$ permits miniature Sagnac loops
- switching energy < 10 pJ