The measurement of a beam waist of laser beam by Knife Edge method

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Knife-edge method

A common technique in the laboratory for measuring the beam waist parameter of a Gaussian beam is knife-edge technique. The intensity of Gaussian beam in the x-y plane described by

$$I(x,y) = I_0 \exp\left[-\frac{(x-x_0)^2+(y-y_0)^2}{w_0}\right], \tag{1}$$

where w_0 is beam waist, I_0 is the peak intensity at the center of the beam, located at x_0 and y_0. The blade is placed on translation stage, and the stage is moved along x-axis as shown in figure 1. When beam is partially blocked by the blade, the transmitted power measured by photodiode is obtained by [1, 2]

$$P(x) = P_0 + \frac{P_{max}}{2}\left[1+\mathrm{erf}\left(\frac{\sqrt{2}(x-x_0)}{w_0}\right)\right], \tag{2}$$

where P_0 is a background power, P_{max} is a maximal power, and erf is the error function.

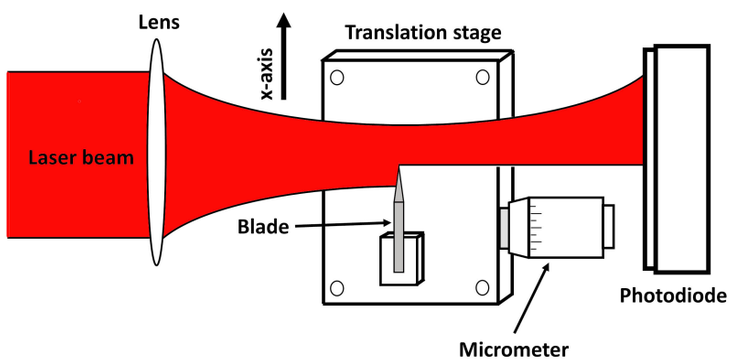

Figure 1. A scheme for the measurement of laser beam waist using the knife-edge technique.

Python script

This is a Python script for estimating of a beam radius using knife edge method

```
"""
This is a  script for estimating of a beam radius using knife edge method
"""
import pandas as pd
import numpy as np
import math
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit
from scipy import special
from sklearn.metrics import r2_score
# Take data from csv file (excel)
data1 = pd.read_csv('vertical_beam.csv')
# take value from CSV file
x=data1['Position (mm)'].values
y=data1['Power (mW)'].values
# difine function for curve fitting
def funct_1(x,x0,p0,p_max,w):
return p0+(p_max/2)*(1-special.erf(math.sqrt(2)*(x0-x)/w))
# initial guesses for parameters
c0=[7,0,0.342,0.5]
# fit curve with function
c,cov = curve_fit(funct_1,x,y,c0)
#define the fitting function
yp=funct_1(x,c[0],c[1],c[2],c[3])
print('x0 = %.2f mm'% (c[0]))
print('Background light =  %.3f mW'% (c[1]))
print('Maximum power =  %.3f mW'% (c[2]))
print('Beam waist =  %.2f mm'% (c[3]))
# find R^2 value
print('R^2 : %.5f'%(r2_score(y,yp)))
plt.figure()
plt.title('The measurement of a transverse profile of laser beam by Knife Edge method')
plt.xlabel('Position (mm)')
plt.ylabel('Optical power (mW)')
#Plot data
plt.scatter(x,y,alpha=0.5)
#Plot the fitting function
plt.plot(x,yp)
```

References

[1] J. Arnaud, W. Hubbard, G. Mandeville, B. De la Claviere, E. Franke, and J. Franke, "Technique for fast measurement of gaussian laser beam parameters," *Applied optics*, vol. 10, no. 12, pp. 2775–2776, 1971.

[2] M. González-Cardel, P. Arguijo, and R. Díaz-Uribe, "Gaussian beam radius measurement with a knife-edge: a polynomial approximation to the inverse error function," *Applied optics*, vol. 52, no. 16, pp. 3849–3855, 2013.