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Computational simulation of the efficiency in light collection of an optical system with a parabolic mirror

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Abstract
This Project consists in computational simulations written in python aiming to calculate the efficiency of a optical system that already exists. The system is made of a parabolic mirror, a thin lens and an optical fiber. The program is able to calculate the efficiency of the system in converging the rays that are issued from a point source located near the focus to the optical fiber and plot graphics exploring this data

Key words:
Simulations,geometric optics, phyton.

Introduction

This work is part of a bigger project that aims to use a tunneling microscope to analyze the luminescence of nanostructured materials. In particular, is being projected an optical system made of a parabolic mirror, a thin lens and an optical fiber, and the main goal of this project is to study the efficiency of this system in collecting light with the fiber.

It is well known that for a point source located on the focus of a parabolic mirror the light reflected by the mirror can be converged by a lens into its focal point. However, the mirror maybe slightly misaligned and a point source infinitely small does not exist. Therefore, we need to understand the variations of light collection for different points of a sample put near the focus, as well as the misalignment effects.

Results and Discussion

The simulation allows us to notice how rays issued by the isotropic point source near the focus spread as they are reflected by the parabolic mirror and refracted by the lens, until they converge on the optic fiber, that is connected to a spectrometer. In the case that the point source is exactly on the focal point, and considering the real geometry of the components of the system, the collection of the system is about 31% of the total light issued by the source. This collection is very high and consistent with the high solid angle of the mirror that is close to the source and has a large curvature (figure 1).

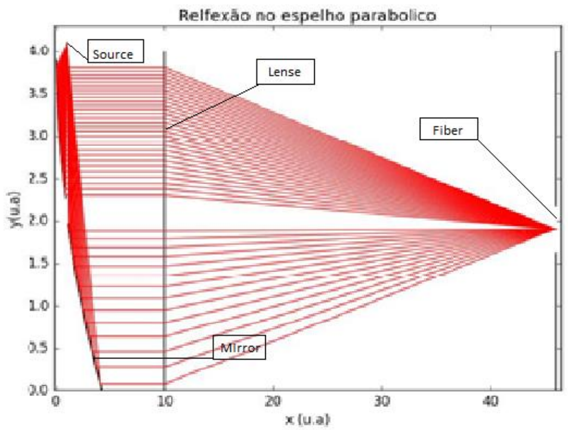

Figure 1. Graphic of the rays issued by the source when it is on the focus.

The disadvantage of optical components with high numerical aperture is that the field vision is reduced. To evaluate the useful size of the sample, simulations have been made of the efficiency in light collection in function of the position of the point source. This results, showed on figure 2, show that on the sample plane we can detect a region of about 20x20microns without loss of efficiency. Also, the depth of focus of the mirror is about 50 microns.

It was noticed that as the source is moved away from the focus, located at (1, 1.4, 0), the efficiency of the system decreases abruptly.

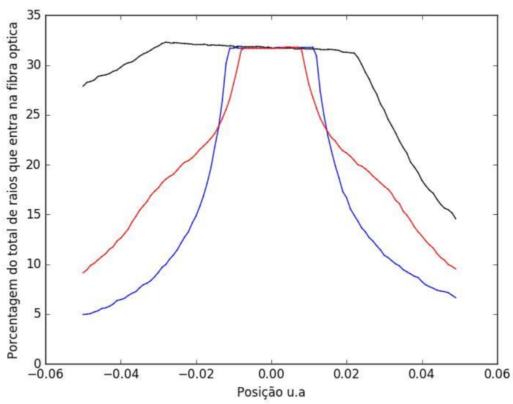

Figure 2. Graphic of the efficiency of light collection as a function of the distance of the source from the focus, moving up and down (black), for left and right (blue) and for front and back(red).

Conclusions

As figure 2 shows, the collection of light of the system is very efficient on points near to the focus. The size of the area where the best collection that can be obtained is similar to the field available on a STM to an image, so this optical configuration will be adequate for the research that will be performed. This confirms that the optical system will have a high performance and will be compatible with the microscope.

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