Computational Physics Homework

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1 Introduction

This first Computational Physics homework is divided into two parts, with the aim of familiarizing with the basic components of Python, such as the sampling of an n-dimensional space, the use of loops and decision making structures, the reading and analysis of a data file, the creation of a plot.

The first exercize is based on the creation of the so-called *Mandelbrot set*, whereas the second is based on the analysis of a data sample using the *least square* fitting procedure.

2 Problem 1

The Mandelbrot set is a set of complex numbers c that satisfy the following property:

$$|z'| < 2 \tag{1}$$

by implementing the following iteration:

$$z' = z^2 + c \tag{2}$$

starting from $z = 0$ and substituting from time to time z with z'.

In order to obtain a plot of this set I wrote a program able to sample randomly the coplex space in the ranges $-2 < x < 2$ and $-2 < y < 2$, and that makes the iteration reported in equation 2 for 100 times in order to verify if the point c satisfies equation 1. While the iteration proceeds, a vector containing the points of the Mandelbrot set is generated, so that they can be plotted. The results are shown in Fig. 2.

The principal restriction on this analysis has been caused by the memory of the machine used for the calculation. Above 10^7 analysed points, in fact, the program had to stop due to insufficient memory. Possible solutions to this problem could be to sample smaller regions of the complex space, or (obviously) to have more memory available. In the code, I also added a code line that allows to print on the terminal the percentage of the process completion, since the time that is needed in order to analyze 10^7 points is about 30 min.

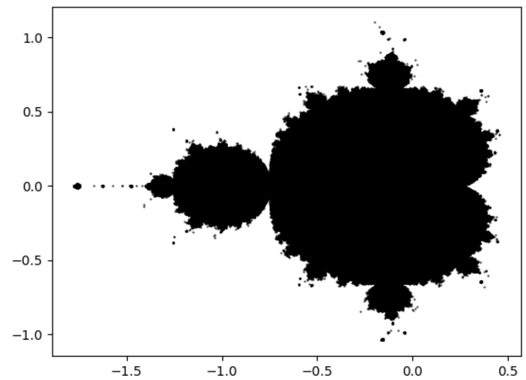

Figure 1: Resulting plot of the Mandelbrot set.

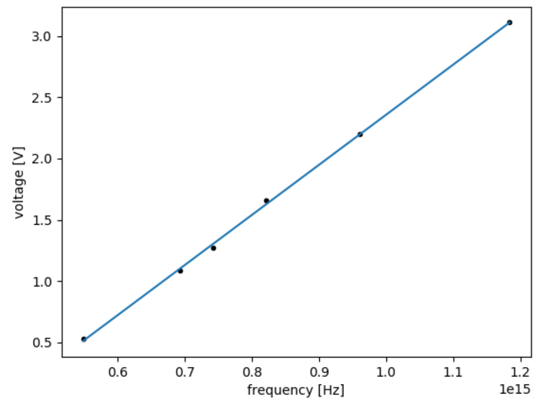

Figure 2: Millikan's experiment datas (black dots) and best fit (blue line).

3 Problem 2

In this exercize, I had a file of data containing the frequencies (in Hertz) and the voltages (in Volt) of the historical Millikan experiment, that had the aim of measuring the photoelectric effect. Through the analysis of such data using a linear fit, based on the *least squares* methods it is possible to hestimate the Plank constant.

The program that I implemented is based on 4 points:

1. it reads the data file, and generates two vectors that contains the frequencies and voltages values, respectively;
2. it calculates the values of the slope and the intercept of the linear fit given by the least squares method relations;
3. it executes a plot with the data and the best fit (see Fig. 2);
4. it calculates the value of the Plank constant.

The results of the fit are:

$$m = 4.088 \cdot 10^{-15}\,\mathrm{V\ Hz^{-1}} \ \text{ and } \ c = -1.731\,\mathrm{V} \tag{3}$$

That allow to obtain the following value of the Plank constant:

$$h = 6.55 \cdot 10^{-34} Js \tag{4}$$

that diverges from the normally accepted value of the Plank constant of the 1.2%.