From mathematics to a nice figure in a LaTeX document: a post-processing chain

Matthieu Haefele

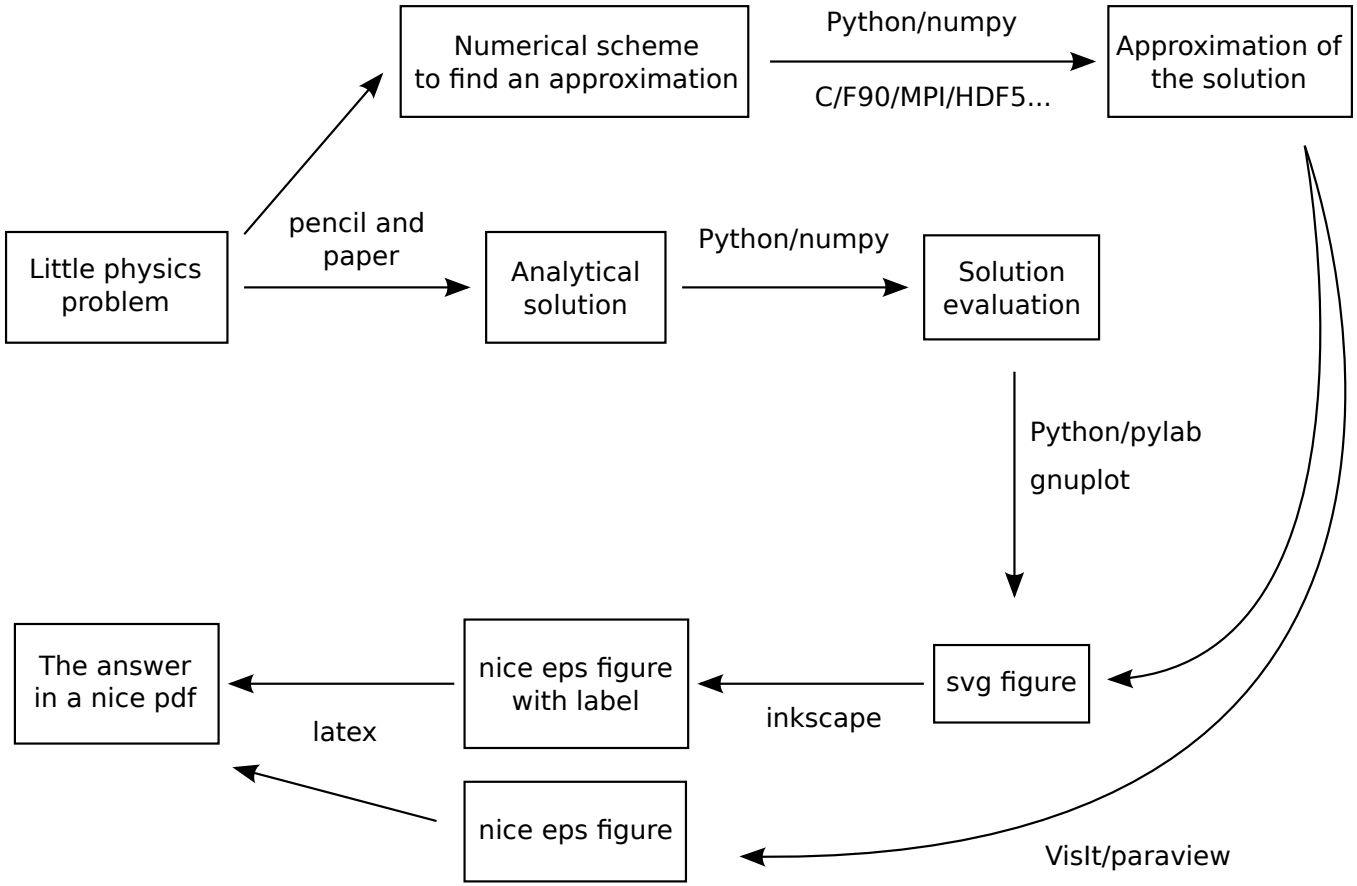
High Level Support Team

Max-Planck-Institut für Plasmaphysik, München, Germany

Autrans, 26-30 Septembre 2011,

École d'été Masse de données : structuration, visualisation

A post-processing chain



Learn Python in 1 slide !

```
def myfunction(foo,bar=3):
  " This function computes something useful "
  print "I was called with ",foo,bar
  pi=3.14
  for i in range(11):
    if i%2==0:
      # Writes pi * i = XX
      print "pi *",i,"=",i*pi
    else:
      # Writes i * pi = XX
      print i," *pi =",i*pi

myfunction("superstring")
```

Main Python packages to do numerics

- numpy: implementation of n-d arrays
- matplotlib/pylab: 1D, 2D graphics
- scipy: package based on numpy that soves different dedicated problems
- h5py: Python bindings for the HDF5 library
- f2py, swig: tools to automate the creation of Python bindings from C/F90 codes
- ...

Correction of exo1 in Python

```
import numpy
import h5py

tab = numpy.zeros((22,20), dtype=numpy.int32)
f = h5py.File('myfile.hdf5', 'w')
f["MyDataset"]=tab
tab = numpy.ones((8,8), dtype=numpy.int32)
f["MyDataset"][3:11,2:10] = tab
f.close()
```

Gnuplot

- open source software
- can produce 2D and 3D plots
- analytic or numeric functions

Using gnuplot interactively

```
set␣xrange␣[0:4*3.14159]

plot␣sin(x),␣sin(x-3.14159/2),␣"data.txt"␣u␣1:2␣w␣l
pause␣-1
```

- $x \in [0 : 4\pi]$
- plot on the same figure:
  - $\sin(x)$
  - $\sin(x - \frac{\pi}{2})$
  - The second column of the file named data.txt, and plot with lines (w l)
- pause -1 means: do not close the window before I hit the Enter key

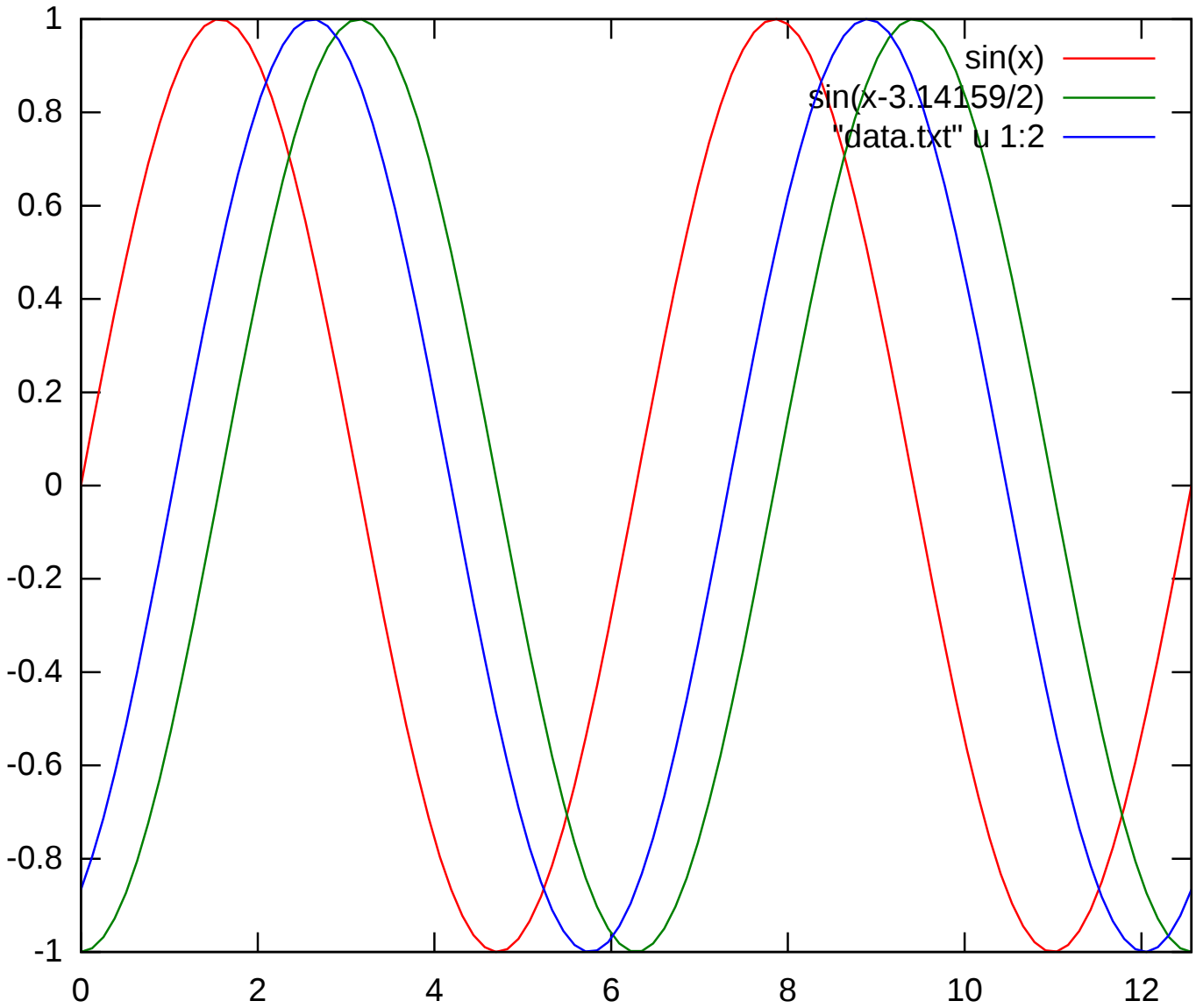
Using gnuplot non interactively

```
set terminal svg
set output "myfig.svg"
set xrange [0:4*3.14159]

plot sin(x), sin(x-3.14159/2), "data.txt" u 1:2 w l
```

- Same figure
- A svg file is created instead of opening a window

Resulting picture



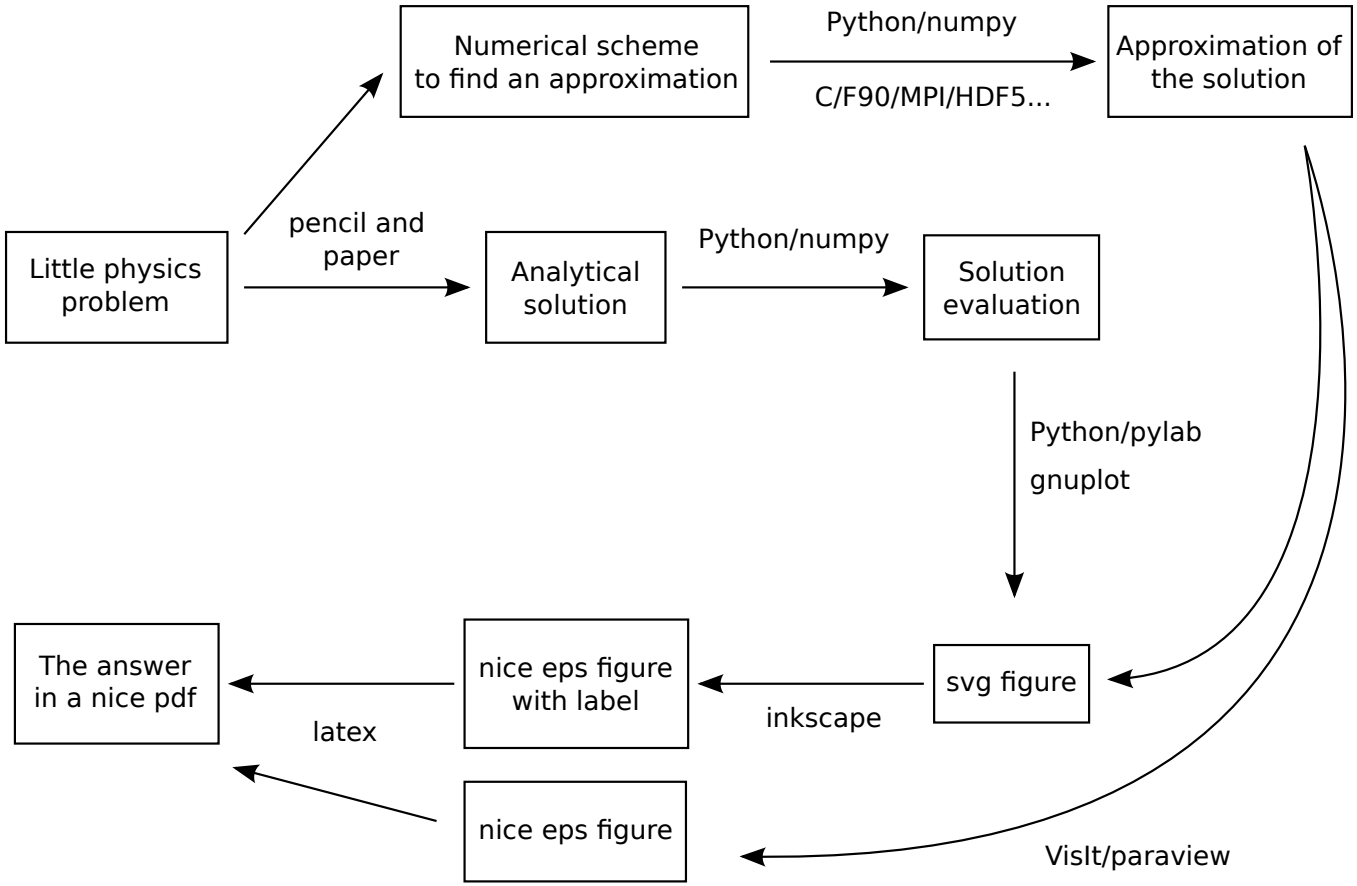
Inkscape software

- Free and open source software
- Vector graphics edition/creation
- Standard Vector Graphics format based (SVG), the W3C standard
- Similar capacities as Illustrator, Freehand, CorelDraw or Xara X

Vector (svg, ps, . . .) vs Raster (png, jpg, tiff, . . .)

- **Raster is an array of dots that “appear” to be shapes**
  - Pro: With sufficient resolution can be photo-realistic
  - Con: Takes up lots of space even for simple geometric representations
  - Con: Difficult to split into component pieces for further editing
- **Vector is real 2D shapes**
  - Pro: Geometric representations scalable to any resolution
  - Pro: Easy to edit component pieces
  - Con: Difficult to do photo-realistic images at small file sizes

A post-processing chain



Hands on

Let us consider the following magnetic diffusion equation

$$\frac{\partial B_y(x,t)}{\partial t} = \eta \nabla^2 B_y(x,t)$$

with an initial discontinuous field given by

$$B_y(x,0) = \begin{cases} B_0 & \text{for} \quad x > 0 \\ -B_0 & \text{for} \quad x < 0 \end{cases}$$

Please find the analytical solution and produce a LaTeX generated pdf file containing figures that illustrates this diffusion.

Hands on correction

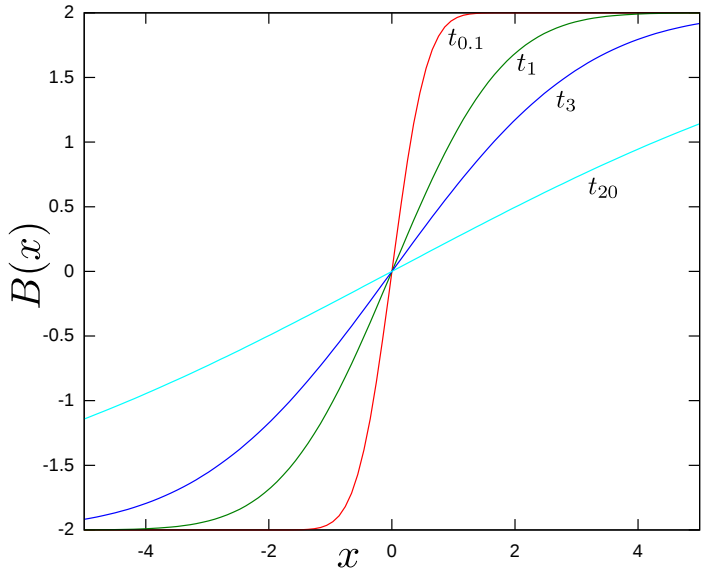
The analytical solution is

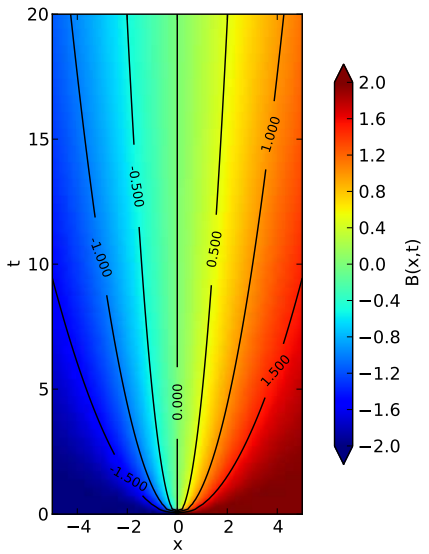
$$B_y(x,t) = B_0 erf(\xi)$$

with $\xi = x/\sqrt{4\eta t}$ and the error function

$$erf(\xi) = \frac{2}{\pi^{1/2}} \int_0^{\xi} e^{-u^2} du$$

Illustration with $\eta = 1$ and $B_0 = 2$





Part of the process in numerical science