Parametric Help

Febrary, 4 2012

Figure 1: Parametric Version 1.17

Contents

1 What is the use of Parametric ?

This program is devoted to the study of forced oscillation of the generalized pendule de Duffing, more precisely:

$$\ddot{x} + \sin x = \epsilon \sin(2\pi f t) \tag{1}$$

The generalized term means simply here that we have replaced the term $(\omega_0^2 + \beta x^2)x$ from Duffing equation without dissipation by $\sin x$. **Parametric** solves numerically equation (1) using a fourth order Runge and Kutta method with constant step size [1].

The results are given as dots in the phase space $(x, \dot{x})$. Each dot is the position in the phase space from a trajectory with initial conditions $x(t=0), \dot{x}(t=0)$ at times $t_n = n/f$, $n = 0, 1, 2...T_{max}$.

2 Using Parametric .

2.1 At program launch

When the program start, one has first to validate some parameters:

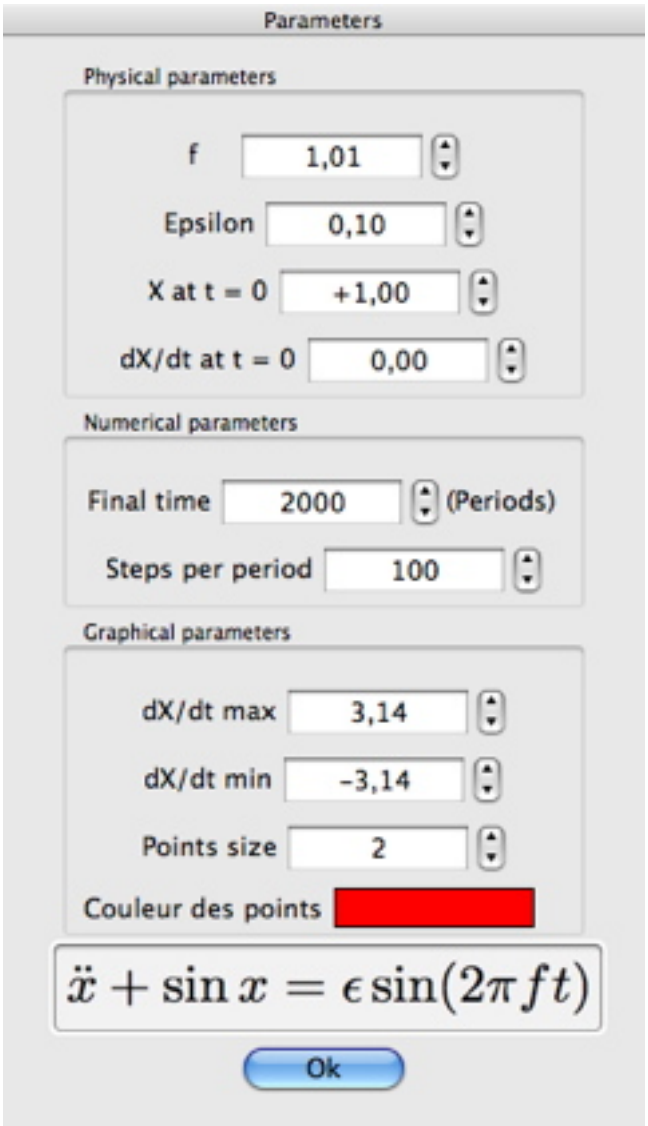

Figure 2: Parameters dialog.

This dialog allows to set the physical parameter [f, ϵ, $x(t=0)$ and $\dot{x}(t=0)$], the numerical parameters [the final time of a trajectory calculation in periods $(1/f)$, the number of time integration step per period] and the graphical parameters: dots color, dots size representing the trajetories and the phase space limitation bounded to $\pm\pi$ pour $\dot{x}$. Since the variable x is an angle there is no need to expand the phase space in the x dimension. The program brings back all dots outside in this interval by adding $\pm 2k\pi$.

When you have selected all your parameters, another dialog appairs:

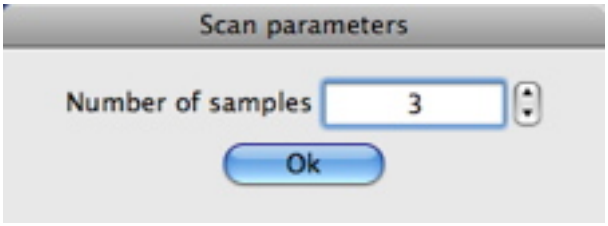

Figure 3: Phase space scannig parameter dialog.

Setting the number of samples N_e allows to scan the phase space automatically with N_e^2 initial conditions. When this value is set, the program launch the calculation of the trajectory with the initial conditions and the color defined by the Parameters dialog (Figure 2). The trajectories computed later will have a random color.

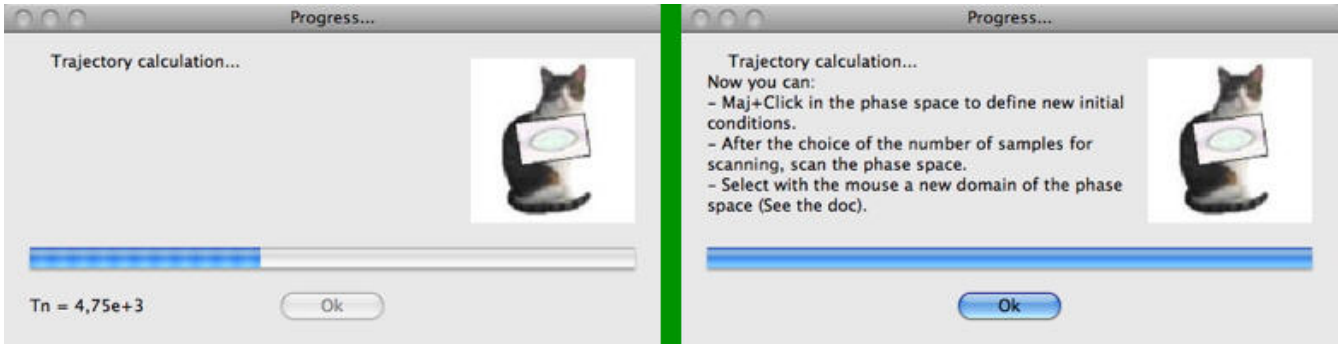

Figure 4: Progress dialog during a trajectory calculation and when the calculation is over.

During the calculation, a progress bar is shown. At the end, you have the dialog of figure 4 and the first trajectory appairs as shwon on 5.

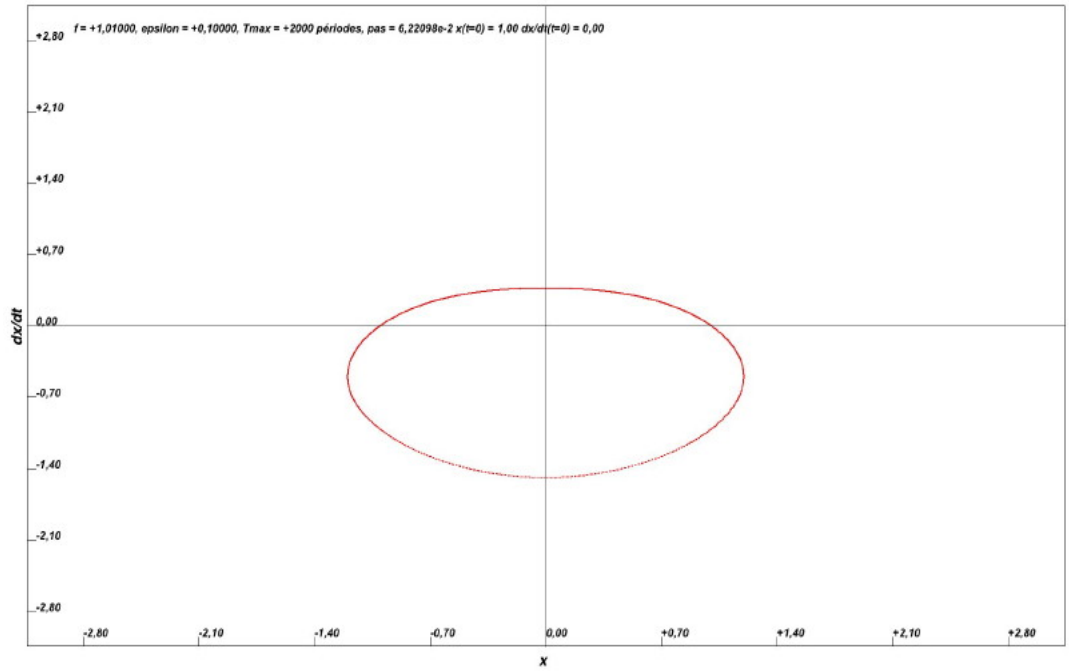

Figure 5: Trajectory in phase space $(x, \dot{x})$ for one initial contition $x(t=0) = 1, v = \dot{x}(t=0) = 0$. Avec $f = 1,01$, $\epsilon = 0,1$, constant step $h = 2\pi/f/100$, computation length 2000 periods (Parameters from figure 2).

2.2 Scanning the phase space.

To scan the phase space you have three methods:

- **Methode A**. Setting only one initial condition.
- **Methode B**. Scanning automatically the phase space.
- **Methode C**. Setting a sub-domain of the phase space with the mouse and applaying the method A and B to this reduced space.

2.2.1 Setting only one initial condition.

Simply pressing the **Maj Key**, make a left click with the mouse at select the initial condition in the phase space. You will ear a confirmation click and the program launch a trajectory calculation.

2.2.2 Scanning automatically the phase space.

You obtain an automatic scanning of the phase space by pressing the button **bouton Balayage**. The number of samples (initial conditions) N_e is defined by the Scanning parameter dialog (cf figure 4), the N_e^2 initial conditions are set arcording to the following procedure:

- $x(t=0) = x_{min} + n\delta x$, n varying from 0 to $N_e - 1$, with $\delta x = (x_{max} - x_{min})/(N_e - 1)$, x_{max} and x_{min} are the boundaries along x of the current window.
- $\dot{x}(t=0) = \dot{x}_{min} + n\delta v$, n varying from 0 to $N_e - 1$, with $\delta v = \dot{x}_{max} - \dot{x}_{min})/(N_e - 1)$, $\dot{x}_{max}$ and $\dot{x}_{min}$ are the boundaries along $\dot{x}$ of the current window.

When the scanning is over, you obtain a result similar to figure 7.

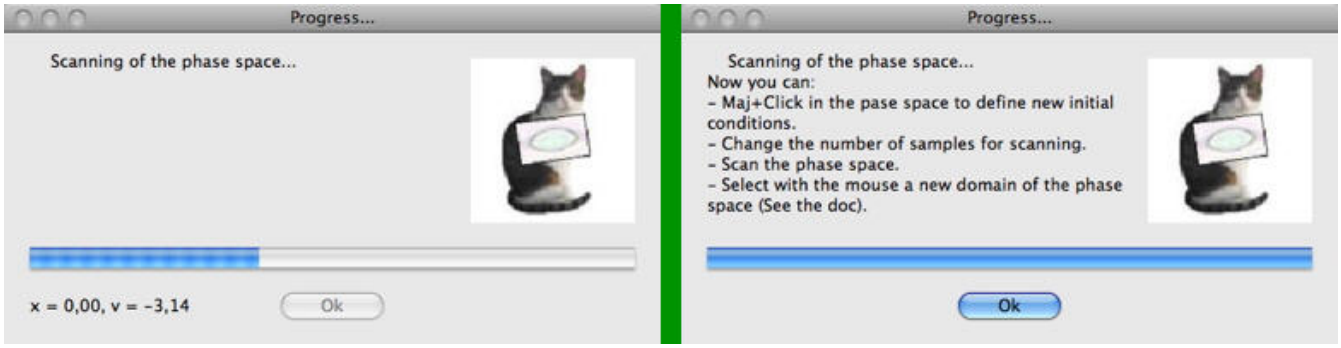

Figure 6: Progress dialog during a scanning calculation and when the scan is over.

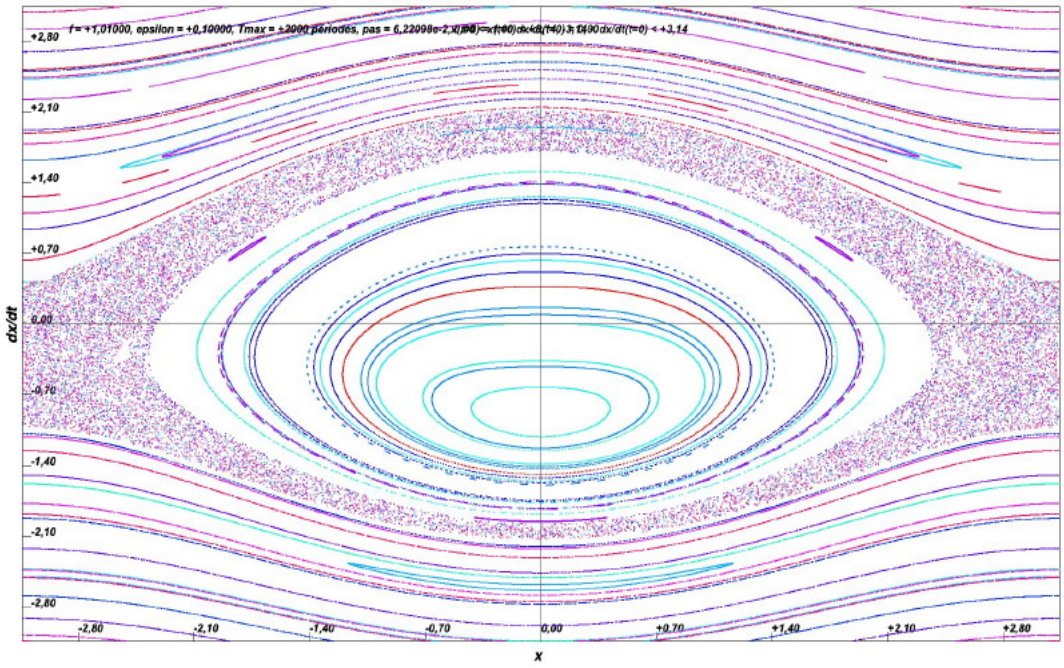

Figure 7: Automatic scanning example: Trajectories in phase space $(x, \dot{x})$ for $x_i(t=0) = x_{min} + i\delta x$, $v_j = \dot{x_j}(t=0) = v_{min} + j\delta v$, $\delta x = (\delta x_{max} - \delta x_{min})/N_e$, $\delta v = (\delta v_{max} - \delta v_{min})/N_e$ pour $0 <= i <= N_e - 1, 0 <= j <= N_e - 1$. With $f = 1,01$, $\epsilon = 0,1$, constant step $h = (2\pi/f)/100$, computation length 2000 periods.

2.3 Setting a sub-domain of the phase space with the mouse.

To define a new phase space domain, make a left-click with the mouse at the upper left corner of your future selection. Move the mouse until the blue rectangle following the mouse reach the whished position. Then make a left-click again. The selection rectangle becomes grey. You can move this rectangle to the correct position. Once you are satisfied by your choice, you can:

- Make a right-click (or Ctrl-Click with one button mouse) to reach a contextual menu.
- Or leave the process by pressing the keybord key **s** or **S**.

With the contextual menu you have the following possibilities (Figure 8):

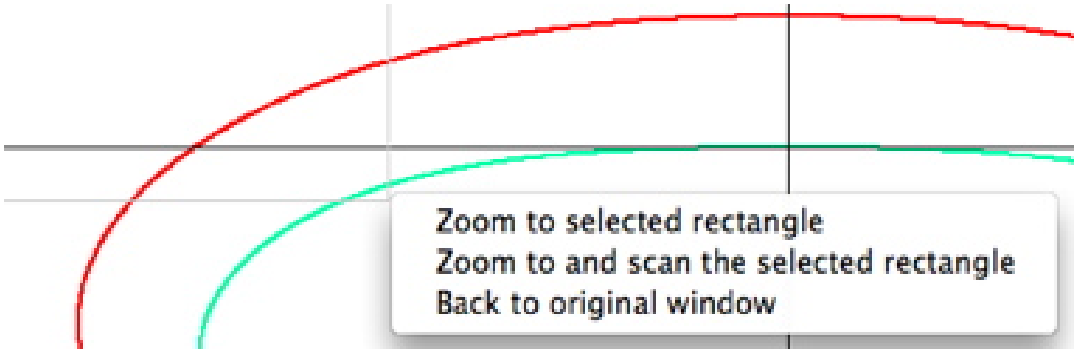

Figure 8: Contextual menu.

Item **Zoomto selected rectangle**: the program set the full window to the seleted phase space. In this new sub-domain, you can set a new initial condition with a Maj+Left Click on any point (Methode A [2.2]) or, pressing the **button Scan**, scan automatically this subdomain (Methode B[2.2]).

Item **Zoom to and scan the seleted rectangle**: you can in one operation zoom in the selected sub-domain and scan automatically this sub-domain (Methode B [2.2]. Then you may use again mthode A to select one initial condition.

Item **Back to original window**: yield you back to the original phase space. Note that this item of the contextual menu is always at your disposal.

Remark a: When you zoom in a sub-domain, the dot size increase automatically.

Remark b: You always go back to the original window by using the item **Back to original window** from **Edition** menu, or it's keyboard shortcut (**Ctrl+G** with Windows ou Linux, **Pomme+G** with Mac-OS). Then you get back the original dot size.

2.4 Changing the dots size.

In some case it can be convenient to change the dots size. This can be done with the Parameters dialog (cf figure 2. One the size has been changed, you can visualize the effect by using the item **Refresh drawing** from menu **Edition** or it's keyboard shortcut (**Ctrl+W** with Windows or Linux, **Pomme+W** with Mac OS).

2.5 Printing the results.

Simply use the item **Print** from the **File** menu.

2.6 Saving the result.

Simply use the item **Save picture** from the **File** menu. The picture is saved as a jpg file.

2.7 Interface langage

With the menu **Preferences** you can select an interface in english or french.

2.8 L'aide.

Simply use the item **Parametric Help** rom the **Help**.

3 Bibliographie

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References

[1] Abramowitz and Segun: *Handbook of Mathematical Functions* p. 897, Eq. 25.5.18, Dover Publications.