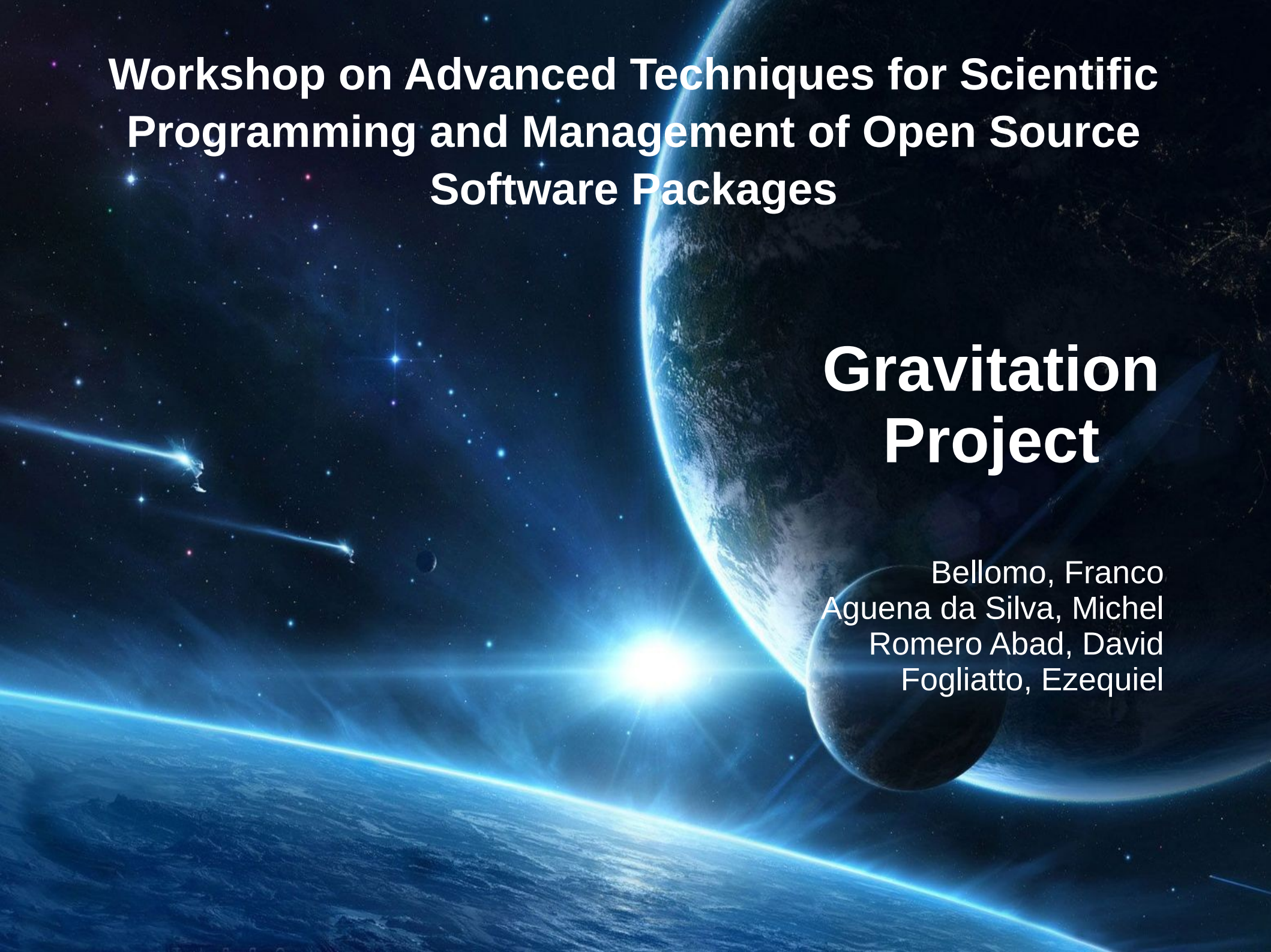

Workshop on Advanced Techniques for Scientific Programming and Management of Open Source Software Packages

Gravitation Project

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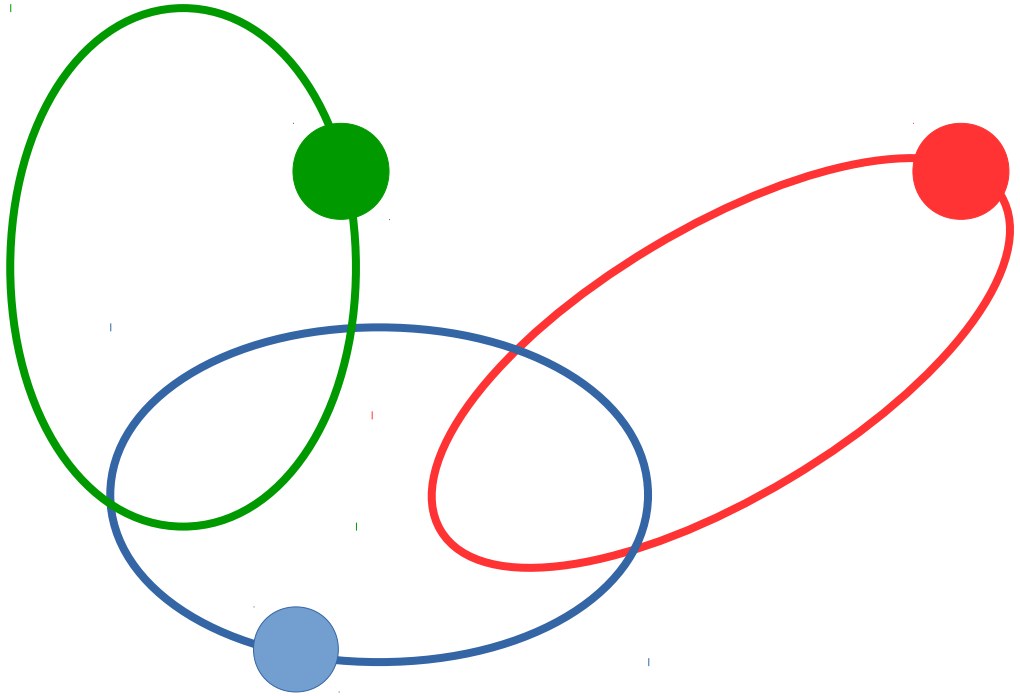
Aguena da Silva, Michel
Romero Abad, David
Fogliatto, Ezequiel

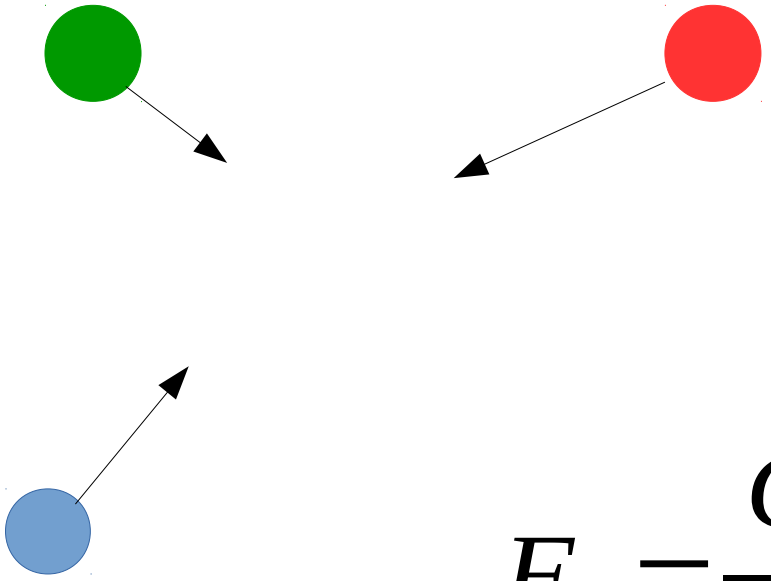
PROBLEM DESCRIPTION



MAIN TASK

Compute the movement of bodies under gravity forces **using collaborative techniques**

PROBLEM DESCRIPTION



MAIN TASK

Compute the movement of bodies under gravity forces **using collaborative techniques**

$$F_{ij} = \frac{G\, m_i m_j}{|\vec{x}_i - \vec{x}_j|^2} \frac{\vec{x}_j - \vec{x}_i}{|\vec{x}_i - \vec{x}_j|}$$

EQUATION DISCRETIZATION

$$\vec{F}_{ij} = m_i g_{ij}\left(\vec{x}_j - \vec{x}_i\right)$$

$$\ddot{\vec{X}}_i = \sum_j g_{ij}\left(\vec{x}_j - \vec{x}_i\right)$$

$$\dot{\vec{X}}_i = \vec{v}_i$$

$$\ddot{\vec{V}}_i = \sum_j g_{ij}\left(\vec{x}_j - \vec{x}_i\right)$$

$$\begin{bmatrix} X' \\ V' \end{bmatrix} = \begin{bmatrix} 0 & \text{Identity} \\ \begin{matrix} g & 0 \\ 0 & g \end{matrix} & 0 \end{bmatrix} \begin{bmatrix} X \\ V \end{bmatrix}$$

$$\dot{\vec{\alpha}} = M\,\alpha$$

EQUATION DISCRETIZATION

Explicit Euler

$$\vec{\alpha}_{n+1} = \vec{\alpha}_n + \delta t\, M\, \vec{\alpha}_n$$

Crank-Nicholson

$$\vec{\alpha}_{n+1} = \vec{\alpha}_n + \frac{\delta t}{2}\left[M\,\vec{\alpha}_{n+1} + M\,\vec{\alpha}_n\right]$$

Runge – Kutta 4th order

$$\vec{\alpha}_{n+1} = \vec{\alpha}_n + \frac{1}{6}\left(K_1 + 2K_2 + 2K_3 + K_4\right)$$

$$\begin{bmatrix} X' \\ V' \end{bmatrix} = \begin{bmatrix} 0 & \text{Identity} \\ \begin{matrix} g & 0 \\ 0 & g \end{matrix} & 0 \end{bmatrix} \begin{bmatrix} X \\ V \end{bmatrix}$$

$$\dot{\vec{\alpha}} = M\,\alpha$$

Gravitation project

PYTHON + GIT + GITHUB

```
class Gravitation(object):
    """ This is the main gravitation wrapper"""
```

→ List of bodies
Time advancement

```
class Body(object):
    """ Base class for space objects"""
```

→ Mass, position, velocity

```
class make_plot(object):
    """Class designed for runtime plotting"""
```

→ Runtime plotting
Image and video
Multi-processing

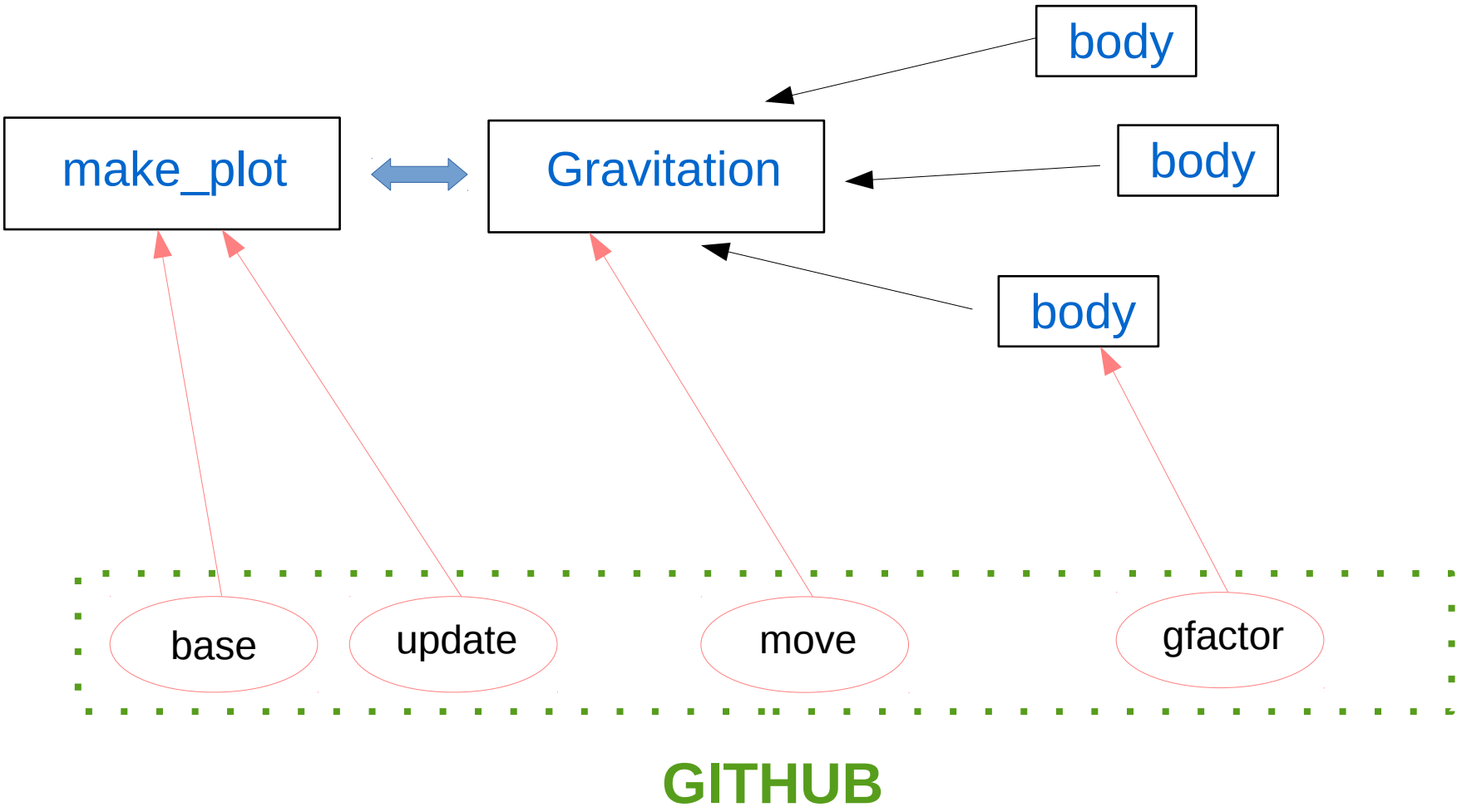
```
def main():
    """Main function"""
```

→

```
usage: Main.py [-h] [--method METHOD] [--tstep TSTEP]
[--file FILENAME] [--plot] [--profile] [--nsteps NSTEPS]
[--config][--confile CONFIG_FILE]
```

Gravitation project

PYTHON + GIT + GITHUB



Gravitation project

2015 ICTP-SAIFR School - Gravitaion Project

65 commits | **1** branch | **0** releases | **3** contributors

branch: **master** GProject / +

Merge branch 'master' of https://github.com/fnbellomo/GProject

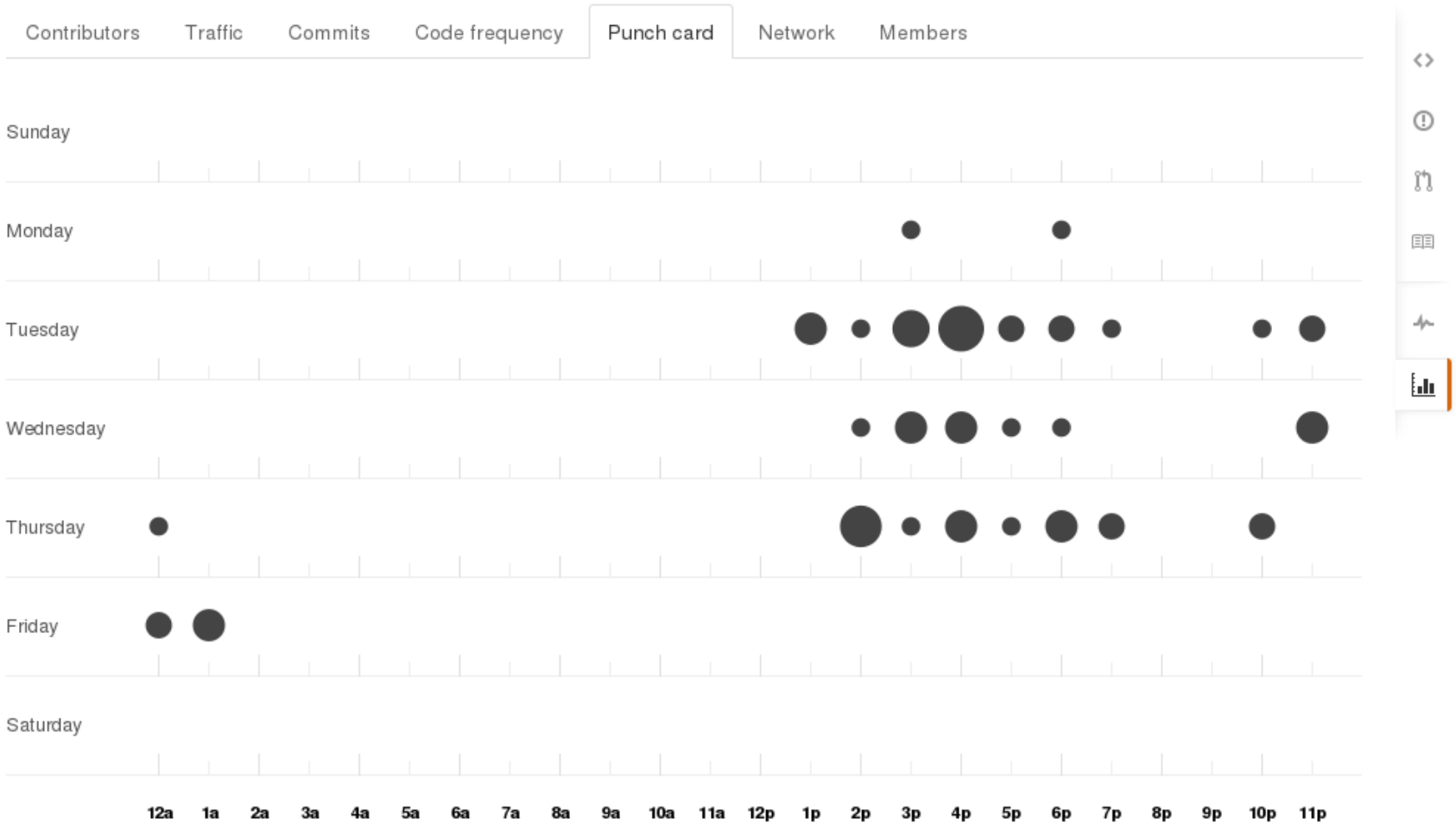
fnbellomo authored an hour ago — latest commit `019976cd35`

Gravitation	Merge branch 'master' of https://github.com/fnbellomo/GProject	an hour ago
LICENSE	Initial commit	3 days ago
Main.py	--mp option to make plot with multiprocessing	an hour ago
README.md	Initial commit	3 days ago
config.py	saving the plot made optional	7 hours ago
generate_people.py	add file that generates workshop members	4 hours ago
test_bodies.dat	Correction to update() in class gravitation. Remove RK.py	2 days ago

ICTP SAIFR

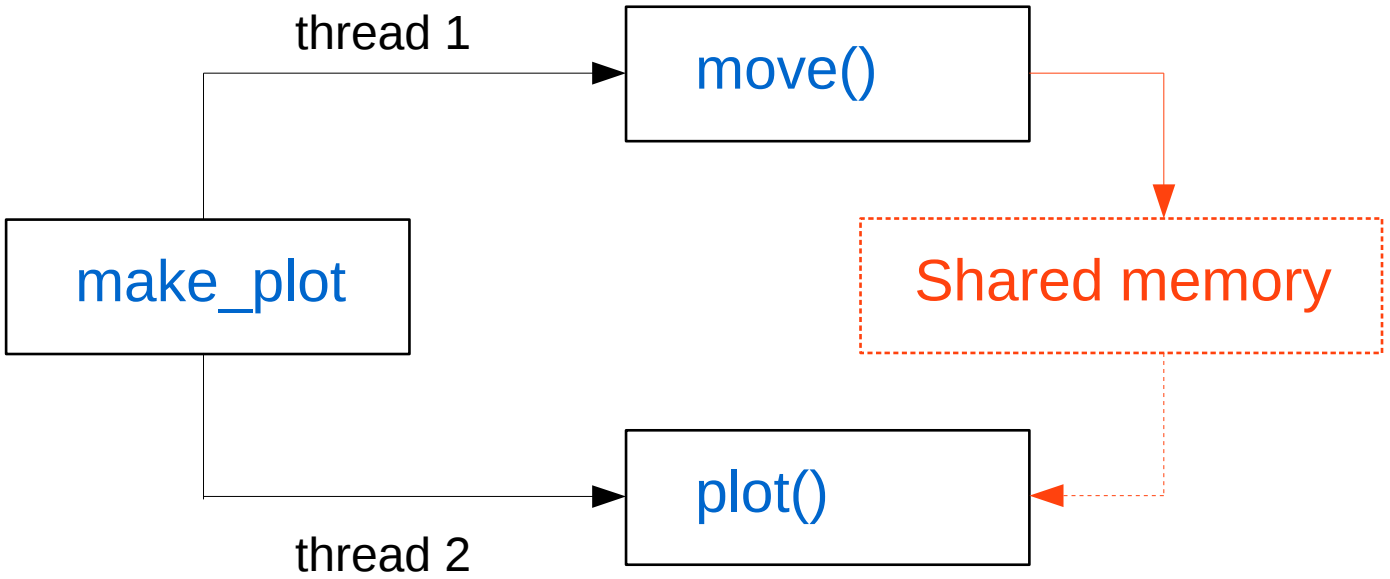
Workshop on Advanced Techniques for Scientific Programming and Management of Open Source Software Packages

Gravitation project



make_plot

- First approach: sequential plotting
- Second approach: multi-processing



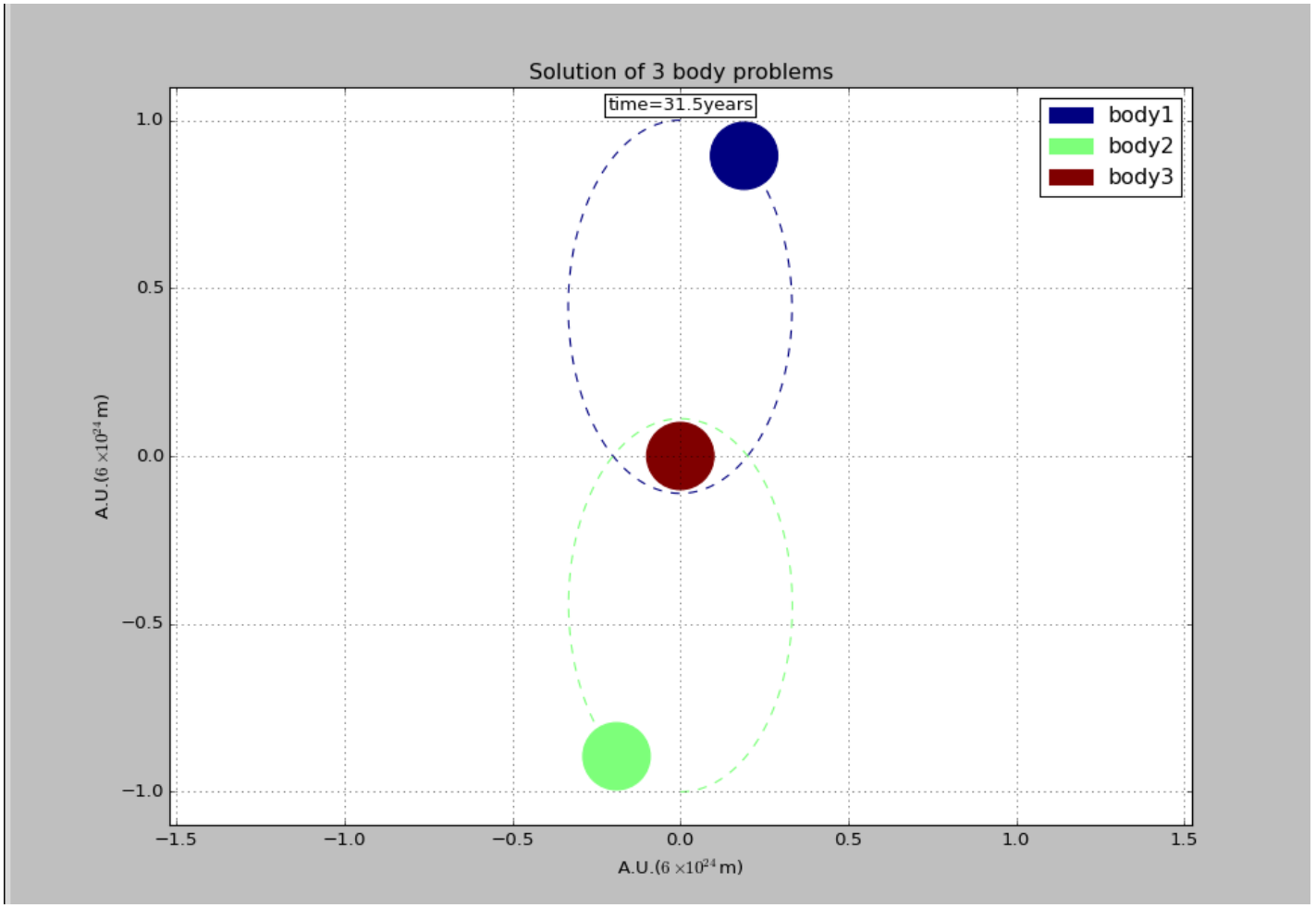
LATEST VERSION

A python program that integrates the equation of movement for an arbitrary number of bodies

Main features

- **Collaborative project**
- Command-line options. Reads data and options from file or during runtime
- Several numerical methods: Explicit Euler, Crank-Nicholson, Runge-Kutta4, **adaptive Runge-Kutta**
- Runtime plotting with multiprocessing

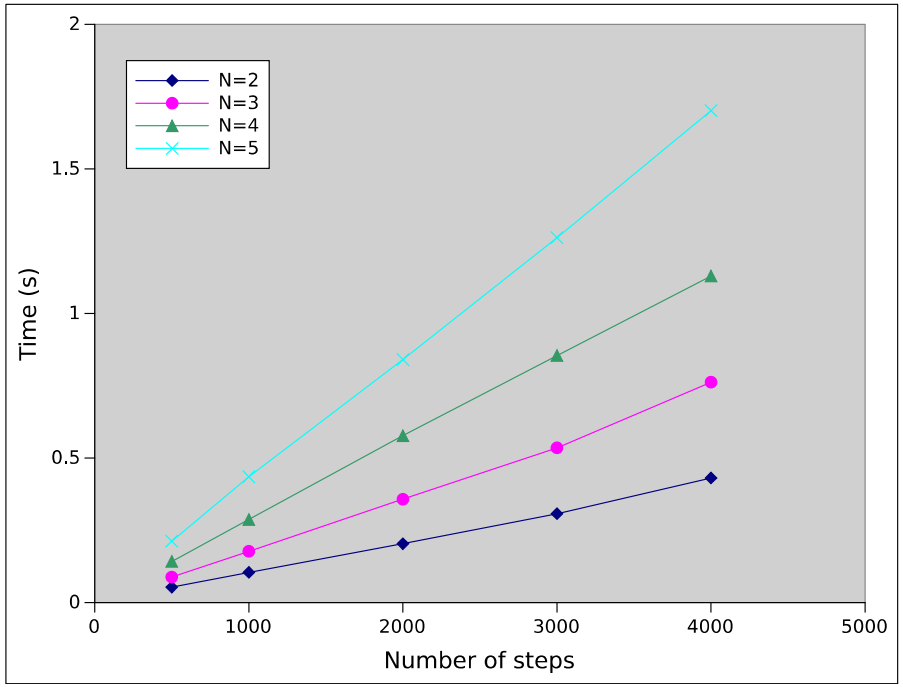
SOME RESULTS

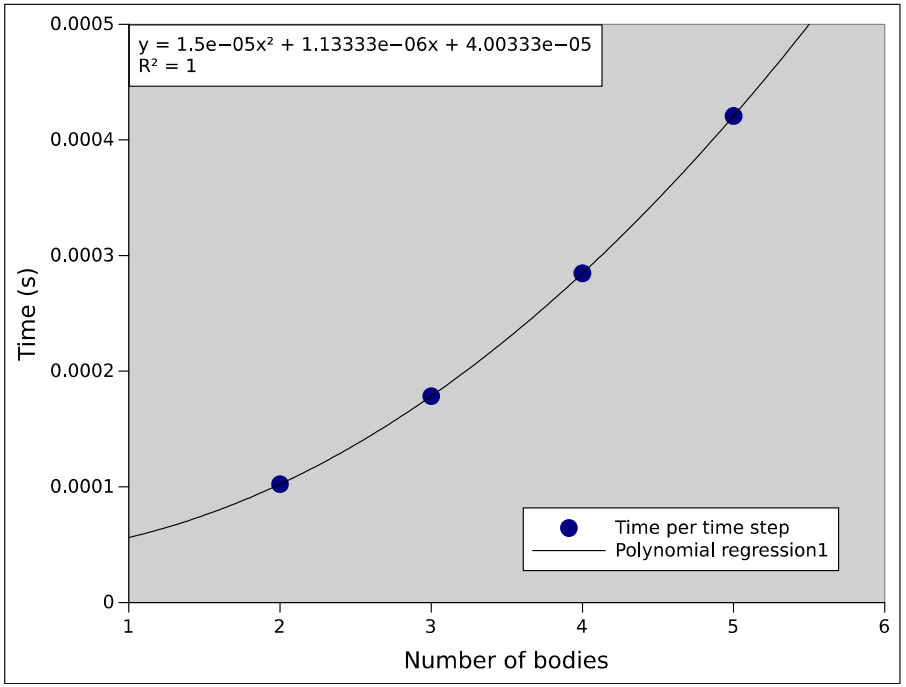


PROFILING

```
import cProfile, pstats

Pr = cProfile.Profile()
pr.enable()
pr.disable()
```





PROFILING

99039 function calls in 0.535 seconds

Ordered by: standard name

```
ncalls  tottime  percall  cumtime  percall filename:lineno(function)
 45000    0.223    0.000    0.223    0.000 Body.py:20(gfactor)
     3    0.000    0.000    0.000    0.000 Body.py:9(__init__)
  3000    0.261    0.000    0.531    0.000 Gravitation.py:107(move)
  3000    0.016    0.000    0.018    0.000 Gravitation.py:175(update)

     6    0.000    0.000    0.000    0.000 Gravitation.py:8(float_list)
  6003    0.001    0.000    0.001    0.000 {len}

     3    0.000    0.000    0.000    0.000 {method 'split' of 'str' objects}
 12000    0.019    0.000    0.019    0.000 {numpy.core._dotblas.dot}
     3    0.000    0.000    0.000    0.000 {numpy.core.multiarray.zeros}
     1    0.000    0.000    0.000    0.000 {open}
     4    0.000    0.000    0.000    0.000 {print}
 30002    0.011    0.000    0.011    0.000 {range}
```

DOCUMENTATION

UNIT TESTS

```
import unittest
import doctest

class TestProject(unittest.TestCase):
    """Testing Body class"""
```

Gravitation project

WHAT WE LEARNED?

- **Working in collaboration is not easy!**
- Implementation of good programming dferfgfv
- Use of Control Version Software

TO DO

- Rewrite class design
- Split the program into a larger number of independent modules
- Optimize calculations

Thanks!

Any questions?

Gravitation project