Computational Astrophysics

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2022

Computational Astrophysics

- Introduction to Computational Astrophysics
- Concepts of High-Performance Computing
- Numerical methods
  - Numerical Integration
  - Solving ordinary differential equations
- Summary of Astrophysical processes
  - Boltzman equation for a system of N-bodies
  - Gravity
  - (Magneto-)Hydrodynamics
- Gravity Solver, Tree codes
  - Direct simulation
  - Eulerian methods: PM, AMR
  - Lagrangian methods: trees and multiple expansions
  - Hybrid methods: TreePM, (A)P3M
- Gravity Solver, Grid codes
  - Eulerian methods: AMR
  - Lagrangian methods: SPH

What is your background?

Have you programmed before? What about C? and in parallel? What do you want out of this course? (the coding tutorials are higly adaptable!)

Computational Astrophysics: Lecturers

- Prof. Alexander Knebe, Mod. 8 316, alexander.knebe@uam.es
- Dr. Daniel Ceverino, Mod. 8 303, daniel.ceverino@uam.es
- Prof. Gustavo Yepes, Mod. 8 307, gustavo.yepes@uam.es
- Dr. Violeta González Pérez, Mod. 8 314, violeta.gonzalez@uam.es

Computational Astrophysics: Summary guide

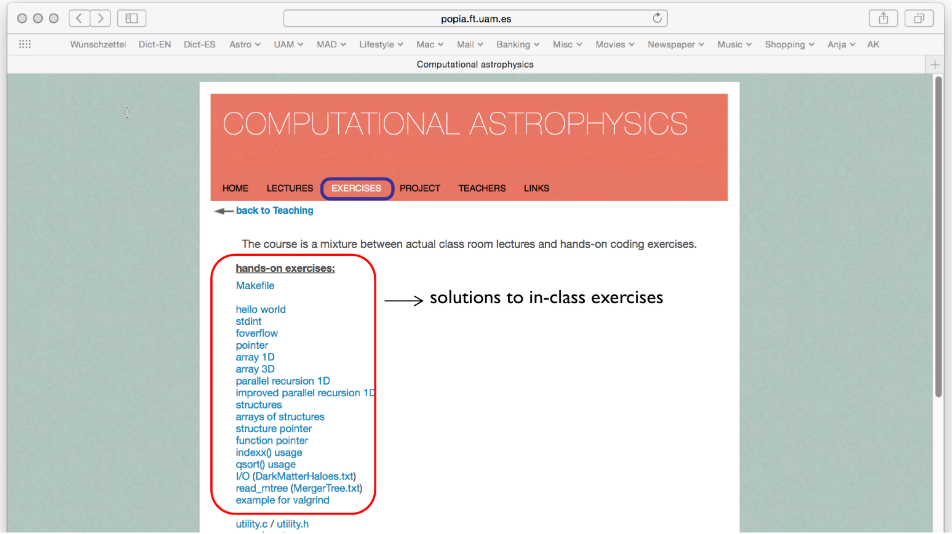
- Course website: `http://popia.ft.uam.es/aknebe/page3/compastro`
- Theory on Thursdays (15pm to 17pm).
- Coding Tutorials on Fridays (12 to 14pm), except the first week.
- Classes will take place in Aula 01.15.SS.201
- Evaluation in 2 parts that need to be passed independently:
  - Attempt to solve 3 problems (50%):
    1. The Mandelbrot series.
    2. The difference between two distinct integration schemes for the equations of motion for two self gravitating bodies.
    3. A 1D code for solving the equations of gas dynamics using the Lagrangian SPH method.
  - Individual project (50%), it can consist of:
    a) Using an existing professional code for the study of an astrophysical system (solar system, galaxy collision, cosmic structure formation).
    b) Write your own code for approaching a physical phenomenon.
    c) Literature research about one of the topics of the course.

Computational Astrophysics: Schedule

ACO classes 2021/22

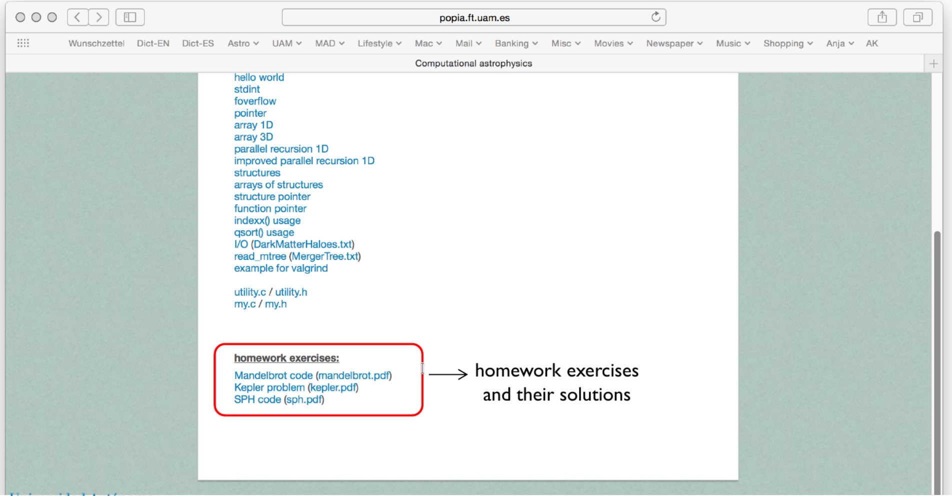
day	date	time	teacher	topic	comments
Thu	24/03/2022	15-17	VGP	Introduction	
Fri	25/03/2022	12-14	VGP	HPC	
Thu	31/03/2022	15-17	VGP	Numerics Review	
Fri	01/04/2022	12-14	AK	Coding Tutorial	
Thu	07/04/2022	15-17	VGP	Physical Processes	
Fri	08/04/2022	12-14	AK	Coding Tutorial	Mandelbrot handout, Project discussion
Thu	14/04/2022		---------	---------	semana santa
Fri	15/04/2022		---------	---------	semana santa
Thu	21/04/2022	15-17	VGP	Tree Codes	
Fri	22/04/2022	12-14	AK	Coding Tutorial	Kepler handout, Mandelbrot solution
Thu	28/04/2022	15-17	DC	grid N-body	
Fri	29/04/2022	12-14	AK	Coding Tutorial	SPH handout, Kepler solution
Thu	05/05/2022	15-17	GY	Hydrodynamics	
Fri	06/05/2022	12-14	AK	Coding Tutorial	
Thu	12/05/2022	15-17	GY	Hydrodynamics	
Fri	13/05/2022	12-14	AK	Coding Tutorial	
Thu	19/05/2022	15-17	GY	Hydrodynamics	
Fri	20/05/2022	12-14	AK	Coding Tutorial	SPH discussion
Thu	26/05/2022		all	project presentations	
teachers	Alexander Knebe (AK), Violeta Gonzalez-Perez (VGP), Gustavo Yepes (GY), Daniel Ceverino (DC)				

Coding tutorials: weekly excersises

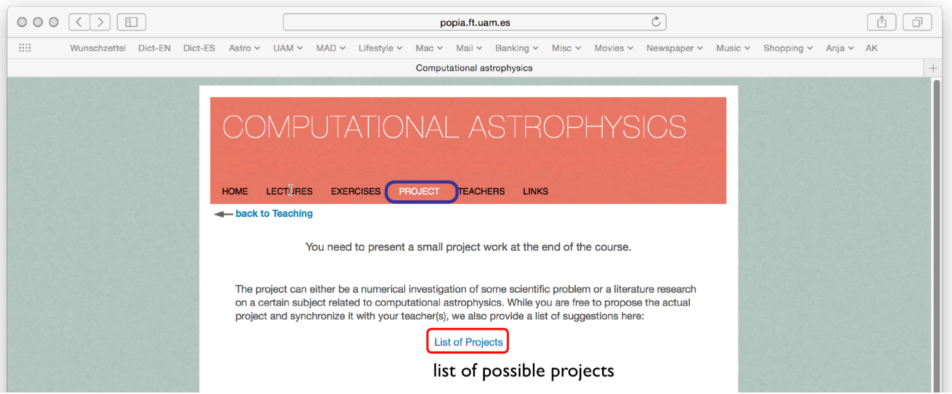


Evaluation: attempt to write code for 3 problems (50%)

In order to pass this subject you need to attempt the following 3 excersises:



Evaluation: individual projects (50%)



You can also come up with your own project. Talk to us!

Evaluation: retake exams

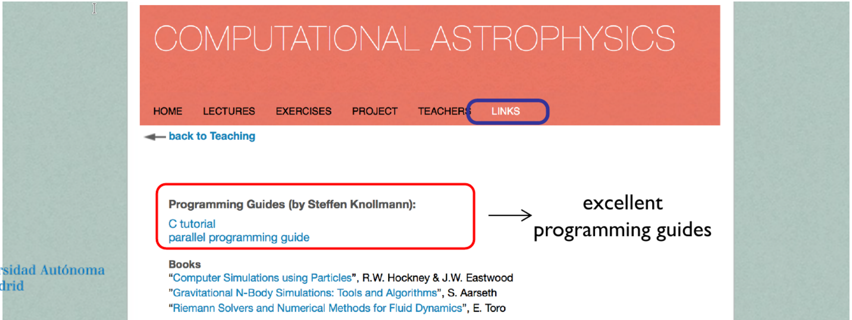
Students will only be permitted to attend the retake exam if they fail one or both of the evaluable parts (excersises and project).
The retake exam will be a written exam, lasting 2 hours. No books will be permitted.

Coding in C

```c
#include <stdio.h>
int main() {
   // printf() displays the string inside quotation
   printf("Hello, World! \n");
   return 0;
}
```

```
> gcc -o p hello.c
> ./p
```

To compile, in general, you will be using the **Makefile** provided in the course website: http://popia.ft.uam.es/aknebe/page3/files/ComputationalAstrophysics/exercises/Makefile.



→ excellent programming guides

Coding in C: set-up

Throughout this course, you are going to do hands-on coding in C. Thus, you will need to install on your laptop:

- The **gcc** compiler:
  - Mac: http://hpc.sourceforge.net/.
  - Other OS: https://gcc.gnu.org/.
- A way to write your code:
  - In Linux and Mac you have already available a Terminal application and an editor (vi, emacs, gedit, etc.).
  - In Windows you could install the Windows Subsystem for Linux (WLS), use Visual Studio or an other integrated development environment (IDE) or even use the virtual linux in the UAM virtual PCs (you will need the UAM VPN) plus OneDrive; https://servidorlibreuam.com/pc-virtual-de-la-uam/.

What tools are you going to use?

Do you know what you're going to use? Do you want to clarify any of the above now?