



# Computational Astrophysics

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2023

# Computational Astrophysics

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

# Computational Astrophysics: Lecturers

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- Dr. Daniel Ceverino, Mod. 8 303, [daniel.ceverino@uam.es](mailto:daniel.ceverino@uam.es)
- Dr. Weiguang Cui, Mod. 8 312, [weiguang.cui@uam.es](mailto:weiguang.cui@uam.es) (coordinator).
- Dr. Violeta González Pérez, Mod. 8 314, [violeta.gonzalez@uam.es](mailto:violeta.gonzalez@uam.es)
- Prof. Gustavo Yepes, Mod. 8 307, [gustavo.yepes@uam.es](mailto:gustavo.yepes@uam.es)

# Computational Astrophysics: Summary guide

- Course material in Moodle and for information from previous years:  
<http://popia.ft.uam.es/ACO/>
- 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** (needed to be able to present the project):
    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** (description to be uploaded **28th April**; 12 min. presentation **25th May**), 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

Secretaría Virtual

32566-ACO classes 2022/23

day	date	time	teacher	topic	comments
Thu	23/03/2023	15-17	VGP	Introduction	
Fri	24/03/2023	10-12	VGP	HPC	
Thu	30/03/2023	15-17	VGP	Numerics Review	
Fri	31/03/2023	10-12	WC	Coding Tutorial	
Thu	06/04/2023		-----	-----	semana santa
Fri	07/04/2023		-----	-----	semana santa
Thu	13/04/2023	15-17	VGP	Physical Processes	
Fri	14/04/2023	10-12	WC	Coding Tutorial	Mandelbrot handout, Project discussion
Thu	20/04/2023	15-17	DC	Tree Codes	
Fri	21/04/2023	10-12	WC	Coding Tutorial	Kepler handout, Mandelbrot solution
Thu	27/04/2023	15-17	DC	grid N-body	
Fri	28/04/2023	10-12	WC	Coding Tutorial	SPH handout, Kepler solution
Thu	04/05/2023	15-17	GY	Hydrodynamics	
Fri	05/05/2023	10-12	WC	Coding Tutorial	
Thu	11/05/2023	15-17	GY	Hydrodynamics	
Fri	12/05/2023	10-12	WC	Coding Tutorial	
Thu	18/05/2023	15-17	GY	Hydrodynamics	
Fri	19/05/2023	10-12	WC	Coding Tutorial	SPH discussion
Thu	25/05/2023	10-14	WC+VGP+GY+DC	project presentations	
teachers	WC: Weiguang Cui (UAM, coordinator), VGP: Violeta Gonzalez-Perez (UAM), DC: Daniel Ceverino (UAM) GY: Gustavo Yepes (UAM)				

# Coding tutorials: weekly excersises

The screenshot shows a web browser window with the address bar at `popia.ft.uam.es`. The website has a navigation bar with links: Wunschezettel, Dict-EN, Dict-ES, Astro, UAM, MAD, Lifestyle, Mac, Mail, Banking, Misc, Movies, Newspaper, Music, Shopping, Anja, and AK. Below this is a sub-header 'Computational astrophysics'. The main content area has a red header 'COMPUTATIONAL ASTROPHYSICS' and a navigation menu with 'HOME', 'LECTURES', 'EXERCISES' (highlighted with a blue box), 'PROJECT', 'TEACHERS', and 'LINKS'. A blue arrow points from 'EXERCISES' to the text 'back to Teaching'. Below this, a paragraph states: 'The course is a mixture between actual class room lectures and hands-on coding exercises.' A red box highlights a list of 'hands-on exercises' with an arrow pointing to the text 'solutions to in-class exercises'. The list includes: Makefile, hello world, stdint, foverflow, pointer, array 1D, array 3D, parallel recursion 1D, improved parallel recursion 1D, structures, arrays of structures, structure pointer, function pointer, indexx() usage, qsort() usage, I/O (DarkMatterHaloes.txt), read\_mtree (MergerTree.txt), and example for valgrind. At the bottom of the list are the files 'utility.c' and 'utility.h'.

popia.ft.uam.es

Wunschezettel Dict-EN Dict-ES Astro UAM MAD Lifestyle Mac Mail Banking Misc Movies Newspaper Music Shopping Anja AK

Computational astrophysics

COMPUTATIONAL ASTROPHYSICS

HOME LECTURES **EXERCISES** PROJECT TEACHERS LINKS

← back to Teaching

The course is a mixture between actual class room lectures and hands-on coding exercises.

hands-on exercises:

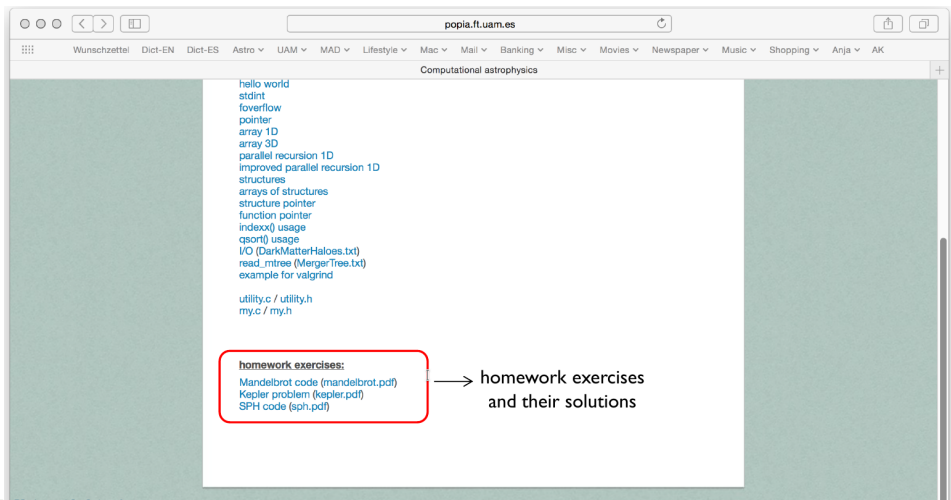
- Makefile
- hello world
- stdint
- foverflow
- pointer
- array 1D
- array 3D
- parallel recursion 1D
- improved parallel recursion 1D
- structures
- arrays of structures
- structure pointer
- function pointer
- indexx() usage
- qsort() usage
- I/O (DarkMatterHaloes.txt)
- read\_mtree (MergerTree.txt)
- example for valgrind

utility.c / utility.h

→ solutions to in-class exercises

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

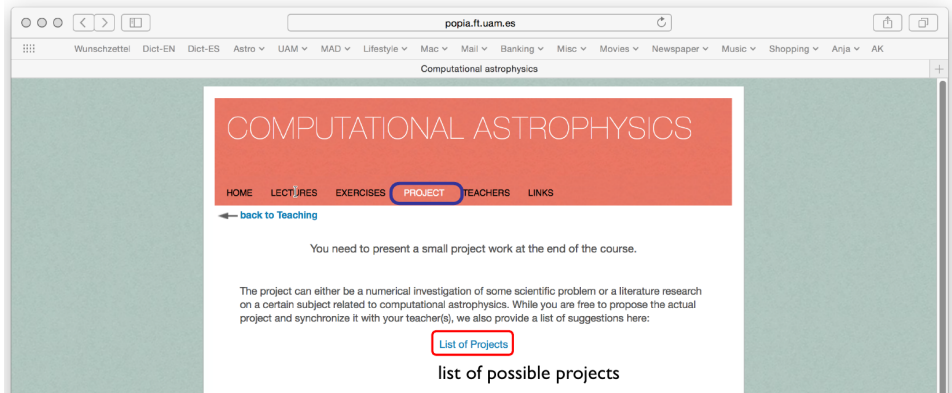
In order to pass this subject you need to attempt the following 3 excersises:



# Evaluation: individual projects

Presentations: **25th May**

Deadline to upload to Moodle a paragraph describing your chosen project: **28th April.**



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



## Evaluation: retake exams

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Students will only be permitted to attend the retake exam if they fail one or both of the evaluable parts (excercises and project).

The retake exam will be a written exam, lasting 2 hours. No books will be permitted.

