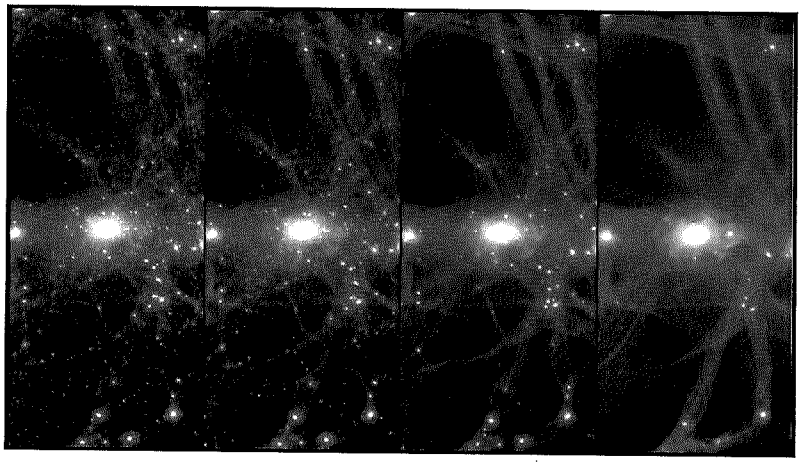
Massimo Ricotti

- Main
- Research
- Teaching
- Vita
- Publications
- Personal

- Fall14:ASTR415
- Spr14:ASTR615
- Fall12:ASTR601
- Spr12:ASTR622
- Fall11:ASTR615
- Spr11:ASTR340
- Fall10:ASTR415
- Fall09:ASTR601
- Spr09:ASTR415
- Fall08:ASTR340
- Spr08:ASTR688
- Spr08:ASTR688
- Fall07:ASTR340
- Spr07:ASTR415
- Fall06:ASTR601
- Spr06:ASTR688
- Fall05:ASTR601

Astronomy 415: Fall 2014

Computational Astrophysics



This course will provide the astronomy student with a basic knowledge of numerical methods in astrophysics. By the end of the course students should be comfortable working in a Unix environment, compiling and running codes, and employing a variety of visualization techniques to analyze the results. This process will be motivated by concrete examples of modern problems in astrophysics that demand numerical approaches.

The exact details of the material covered will depend on the existing level of computer sophistication among the class participants. However, in broad outline the major course topics will include linear algebra, root finding, least-square fitting, Monte Carlo methods, numerical integration, N-body methods, fluid dynamics, FFTs and time-series analysis.

Schedule

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Instructor:  Massimo Ricotti
Class:       CSS 2428
Lectures:    Wednesday and Friday from 2:00pm to 3:15pm
First class: Wed Sept 3
Last  class: Fri Dec 12
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What's New?

Sept 5: Survey result posted.
Sept 3: First class

Contact info and Notes

- Office: PSC 1156
- E-mail: ricotti "at" astro "dot" umd "dot" edu
- Phone: (301) 405 5097
- Office hours: TBD or by appointment
- Class web page: http://www.astro.umd.edu/~ricotti/NEWWEB/teaching/ASTR415-14.html

Course Outline

The Syllabus is available in HTML and PDF format.

	Date	Lecture	Reading (NRiC)	Lecture Notes
#1	Sept 3	Introduction to the course	-	-
#2	Sept 5	Computer architecture	Computer architecture	class02.pdf
#3	Sept 10	Introduction to UNIX	tutorial	-
#4	Sept 12	Introduction to C	1.1-1.2, tutorial	-
#5	Sept 17	Examples in C and debugging	1.1-1.2, tutorial	-
#6	Sept 19	Parellel Computing (CPU and GPU)	tutorial	-
#7	Sept 24	Data representation	1.3	class05.pdf
#8	Sept 26	Linear algebra, part 1 (Gauss-Jordan elimination)	2.0-2.3	class06.pdf

#9	Oct 01	Linear algebra, part 2 (LU & SVD decomposition)	2.4-2.6	class07.pdf
#10	Oct 03	Root finding in 1-D	9.0-9.1, 9.4, 9.6	class08.pdf
#11	Oct 08	Root finding in multi-D, and numerical differentiation	5.7	class09.pdf
#12	Oct 10	Statistics and the K-S test	14.0-14.3	class10.pdf
#13	Oct 15	Least-squares fitting	15.0-15.2, 15.4-15.5	class11.pdf
#14	Oct 17	Random numbers and cryptography	7.0-7.2	class12.pdf
#15	Oct 22	Numerical integration	7.6, 4.0-4.4, 4.6	class13.pdf
#16	Oct 24	Integration of ODEs, part 1 (IVPs)	16.0-16.1	class14.pdf
#17	Oct 29	Integration of ODEs, part 2 (leapfrog)	-	class15.pdf
#18	Oct 31	Integration of ODEs, part 3 (stiff ODEs & 2-pt BVPs)	16.6, 17.0	class16.pdf
#19	Nov 05	Integration of ODEs, part 4	-	class17.pdf
#20	Nov 07	*N*-body techniques, part 1	-	class18.pdf
#21	Nov 12	*N*-body techniques, part 2 (PP)	19.0, 19.4-19.6	class19.pdf
#22	Nov 14	*N*-body techniques, part 3 and 4 (PM)	-	class20.pdf class21.pdf
#23	Nov 19	Integration of PDEs, part 1 (ell & hyp)	19.2	class22.pdf
#24	Nov 21	Integration of PDEs, part 2 (hyp & par)	19.2	class23.pdf
#25	Nov 26	Fluid dynamics, part 1 (eqns)	19.3	class24.pdf
-	Nov 28	*no class* Thanksgiving	-	-
#26	Dec 03	Fluid dynamics, part 2 (methods)	-	class25.pdf
#27	Dec 05	Term project presentations	-	-
#28	Dec 10	Term project presentations	-	-
#29	Dec 12	Term project presentations	-	-
-	Likely not covered	Fourier transform, part 1 (intro)	12.0-12.1, 19.4	class26.pdf
-	Likely not covered	Fourier transform, part 2 (FFT)	12.2, 13.0-13.2, 13.4	class27.pdf
-	Likely not covered	Other topics	-	class28.pdf

Textbooks

There are no required textbooks
Recommended:

Numerical recipes in FORTRAN [or in C], by Press, W.H. et al.

Course Grading

- Homework 70%
- Term Project 30%

The homework is the most important part of the class. In class participation is strongly encouraged.

Class Survey Results

The starting level of computer and programming competence of the students in this class (measured the first day of class) is "Novice" as indicated by the result of the class survey. The survey results are available in PDF format. I will start the lectures with simple and, for some of you, obvious concepts and finish with more complex and challenging topics that should entertain even the most experienced students in the class.

Homework

Homework will be assigned every week or every other week. Their due dates will be announced at the time they are assigned. On the due date the students will be expected to turn in their homework in class. The homework turned in will be graded and returned to the students. I will provide solutions and discuss them in class.

Link to Numerical Recipes sources in C and in FORTRAN: it is preferable to compile the recipes as separate files rather than cut and paste the functions into your source code.

Note that in order to use NRiC routines the easiest way is to include nr.h header file and nrutil.c and nrutil.h to use vectors and matrices. You can find these files here.

No homework assigned yet.

Tutorials

- **Introduction to C [PDF/PS] with examples [PDF/PS]**
- **Introduction to Unix [PDF/PS]**
- **Introduction to visualization [PDF/PS]**

Old Class Notes

These notes were part of the "first edition" of this course (ASTR688N) in Spring 2001.

- ***Computer Architecture*** **(Feb 1/01) [HTML/PowerPoint]**
- ***Unix*** **(Feb 13/01; revised Sep 8/03) [HTML/OpenOffice/PDF]**
- ***Data Representation*** **(Feb 15/01) [HTML/OpenOffice/PDF]**

- *Visualization* (Feb 15/01) [HTML/OpenOffice/PDF]
- *Linear Algebra* (Feb 20 & 22/01) [HTML/OpenOffice/PDF]
- *Nonlinear Equations* (Feb 27 & Mar 1/01) [HTML/OpenOffice/PDF]
- *Statistics* (Mar 6/01) [HTML/OpenOffice/PDF]
- *Modeling of Data* (Mar 8/01) [HTML/OpenOffice/PDF]
- *Random Numbers* (Mar 13 & 15/01) [HTML/OpenOffice/PDF]
- *Numerical Integration* (Mar 15/01) [HTML/OpenOffice/PDF]
- *Ordinary Differential Equations* (Mar 27 & 29/01) [HTML/OpenOffice/PDF]

Useful Links

Tutorial on Pointer: TUTORIAL ON POINTERS AND ARRAYS IN C

Debugger's Links: Using GNU's GDB Debugger Debugging Floating Point Exceptions

OpenMP links: OpenMP.org OpenMP Tutorial

Wiki OpenMP

CUDA and GPU computing: Nvidia webpage with examples to download Wiki OpenCL Wiki CUDA

Check out the UMD Astronomy Computing Wiki!

(In the listings below, a "W" link indicates a Wikipedia entry on the topic is available.)

Online Tutorials

- The GNU C Programming Tutorial
- The C Programming Language (also try this one) [W]
- The UNIX Operating System [W]
- Csh scripting tutorial
- HTML: HyperText Markup Language [W]
- LaTeX2e typesetting language (also here) [W]
- SM interactive plotting package
- Emacs text editor [W]

Free Software

- Xfig interactive drawing tool for X Windows [W]
- POV-Ray Persistence of Vision Ray-tracer [W]

General Stuff

- **Doubts about NR? Read their response to critics.**
- **IEEE 754 format for floating point numbers.**
- **CPU Performance:**
  - **LINPACK performance ratings.**
  - **Java-based LINPACK benchmark.**
  - **SPEC benchmarks.**
- **All kinds of neat code.**
- **The Gnu Scientific Library is an alternative to Numerical Recipes. Linux operating systems often include GSL. To use it, follow these steps:**
  1. **In your C source file, #include ‹gsl/gsl_*.h›, where * is based on the name of the GSL function you want to use (consult the website for a list of functions).**
  2. **Call the needed function(s) in your code.**
  3. **Add -lgsl -lgslcblas -lm to the end of your compile line.**
- **Handy random number generator resources.**
- **HotBits: genuine random numbers generated by radioactive decay.**
- **Online computational courses:**
  1. **Physics 594 (University of Tennessee).**
  2. **Computational Physics (University of Vienna).**
  3. **Particle-mesh Techniques (GSFC Summer School).**
- ***N*-body resources:**
  1. **MODEST/MANYBODY (includes a link to NEMO).**
  2. **The *N*-body Shop (University of Washington).**
- **Fluid dynamics resources:**
  1. **CFD Online.**
  2. **Zeus & Athena.**
- **Useful animation links:**
  - **NetPBM utilities**
  - **MPEG utilities**
  - **ppm2fli**
  - **animated GIFs**
- **FFT demo for `sm`.**