

PYL800: Numerical and Computational Methods in Research

Course instructor: Suprit Singh

Course Outline

1. Role of Numerical & Computational Techniques
2. Working Environment -- GNU/Linux, Julia ...
3. Numerical Techniques involved in solving Physics problems
4. 8-10 Projects for you to work on
5. Data handling, interpretation, analysis, and Visualization
6. Git management, Markdown, Presentation, LaTeX

Projects

- [physics/0701150] Accurate numerical solutions of the time-dependent Schrödinger equation
- [1701.08137] Numerical solutions of the time-dependent Schrodinger equation in two dimensions
- [1705.01510] Deformation of horizons during a merger
- [2104.04538] A new measurement of the Hubble constant using Fast Radio Bursts

- [1707.01060] QuantumOptics.jl: A Julia framework for simulating open quantum systems
- [1402.2405] The influence of primordial magnetic fields on the spherical collapse model in cosmology
- [astro-ph/9406050] A Two-Fluid Approximation for Calculating the Cosmic Microwave Background Anisotropies
- A pedagogical model of primordial helium synthesis
- [1703.09598] Caustic Skeleton & Cosmic Web

Evaluation

1. Continuous with weightage of 50 Marks
2. Assignments x 2 with weightage of 10 Marks
3. Minor Exam x 2 with weightage of 20 marks
4. Major Exam x 1 with a weightage of 20 marks

Role of Numerical & Computational Methods

- Physics: an endeavour to explain what we observe!
- Observations \implies Data: structuring, visualisation, and interpretation
- Data \implies Fixing parameters in our models, often statistically, test principles
- Models \implies Predictions: Semi-analytical, Numerical, and Simulations
- Cycle repeats ad infinitum (?)

Thinking about equations - I

- Models are described by Equations, which in turn are made up of variables
- Physical variables have dimensions such as d , distance has dimensions of Length
- Dimensionless numbers, eg., π
- Dimensionless quantities that still carry units eg., angle θ
- But, a computer understands equations and vars as

- $y(t) = y_0 + v_0 t + \frac{1}{2}gt^2$ or $y(t) = 3 + 2t - 5t^2$
- Certain functions are transcendental eg.,

$$\sin u = u - \frac{u^3}{6} + \frac{u^5}{120} - \frac{u^7}{5040} + \dots$$

- Validity requires arguments to be dimensionless!

$$f(t) = \exp \lambda t = 1 + \lambda t + \frac{(\lambda t)^2}{2} + \dots$$

- Define $x := \lambda t$ and λ defines a scale

whoami	rmdir	tail	uniq	ps	sleep	ln
man	rm	date	diff	top	gzip	who
clear	touch	cat	find	kill	gunzip	su
pwd	open	less	grep	killall	tar	sudo
ls	mv	echo	du	jobs	nano	passwd
cd	cp	wc	df	fg	alias	chown
mkdir	head	sort	history	bg	xargs	chmod