# Computational Physics and Astrophysics

## Introduction

Lectures based on course notes by Pablo Laguna and Kostas Kokkotas

revamped by Deirdre Shoemaker

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# General Topics

- Solving nonlinear equations
- Solving systems of equations
- Interpolation, approximation & curve fitting
- Numerical integration
- Numerical differentiation
- Numerical Solution of ODEs
- Numerical Solution of PDEs
- Monte Carlo Methods
- Fourier Analysis

# Textbooks

- A First Course in Computational Physics, Paul L. DeVries and Javier E. Hasbun, 2nd Edition, Jones and Barlett Publishers (2011)
- Numerical Recipes. The Art of Scientific Computing W. H. Press, S. A.Teukolsky, & W. T. Vetterling, 3th Edition, Cambridge University Press (2007)
- Applied Numerical Analysis C. F. Gerald & P. O. Wheatley, 7th Edition, Addison-Wesley (2004)

# Outline

- Solving nonlinear equations
  - Bisection method
  - Linear interpolation
  - Newton Raphson method
- Solving systems of equations
  - Gaussian elimination
  - Iterative methods
  - Eigenvalues & Eigenvectors
  - Nonlinear systems
- Interpolation, approximation & curve fitting
  - Interpolating polynomials
  - Spline Curves
  - Rational function approximations

# Outline

- Numerical Integration
  - Trapezoidal rule
  - Simpson rules
  - Gaussian quadrature
  - Multiple integrals
- Numerical Differentiation
  - Finite Differences
  - Truncation Errors & Convergence
  - Richardson Extrapolation
- Numerical Solution of ODEs
  - Euler's method
  - Runge-Kutta methods
  - Adam's method
  - Prediction-Correction methods
  - Shooting method

# Outline

- Numerical Solution of PDEs
  - Elliptic equations
  - Parabolic equations
  - Hyperbolic equations
- Monte Carlo Methods
  - Simple Monte Carlo integration
  - Von Neumann Rejection Method
  - Maxwell-Boltzmann distribution
  - 2D Ising Model
- Fourier Analysis
  - Fast Fourier Transform
  - Convolution and Correlation