Computational Physics at St. Stephen's College

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Outline

Background

- Period I will be talking about: 2003-2009
- Very conducive environment for innovation in teaching
- Motivated student body - willing to be challenged
- No formal course in computational physics
- Third year project.

Informal Lectures on Computational Physics

- *"In thinking and trying out ideas about "what is a quantum field theory", I found it very helpful to demand that a correctly formulated field theory be soluble by computer, the same way an ordinary differential equation can be solved on a computer, namely with arbitrary accuracy in return for sufficient computing power"*

  Ken Wilson, Nobel Prize Acceptance Speech 1982.

- To formulate a problem in a manner which a computer can solve requires a deep and clear understanding of the underlying laws.
  - Symmetries and conserved quantities
  - Dimensional Analysis
- Python and Visual Python (moved from C to python)
  - Non-linear oscillator
  - Solar System

Aim of these Lectures

To provide a rudimentary tool kit so that you can

- Solve differential equation on a computer - Using Visual Python to simulate solar system (Lec-2)
- Solve a linear partial differential equation on a computer - Laplace equation - variational principle. (Lec-3)
- Simulate quantum or statistical systems - Path integrals on a computer. (Lec-4)

Visual Python in Statistical Physics

- Introduced the idea of Monte-Carlo Simulation of a canonical ensemble in the class.
  - Emphasised fluctuations when the system is in thermal equilibrium.
  - Simulated 2-Dimensional Ising Model
- Student's Response
  - Example project by a student.
  - Third year project on obtaining energy eigenvalues of a SHO using Euclidean path integral.

Visualizing Special Functions using Octave

"Sometimes the patterns embodying special functions are conjured up in the form of pictures. I wonder how useful sines and cosines would be without the images, which we all share, of how they oscillate. In 1960, the publication in J&E of a three-dimensional graph showing the poles of the gamma function in the complex plane acquired an almost iconic status. With the more sophisticated graphics available now, the far more complicated behavior of functions of several variables can be explored in a variety of two- dimensional sections and three-dimensional plots, generating a large class of new and shared insights. "

M. Berry, Why are special functions special, Physics Today 2001.

Special Functions

Aim:

- To bring visual familiarity with special functions
- To visualize the solutions of PDE

Summary

- Computer as a tool for exploration and for developing intuition
- Students feedback:
  - For average student it makes things more interesting
  - For motivated students it allows them to explore more advanced topics