Teaching our Students Astro Computing

BoF B.6 – ADASS XXIX

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- Classroom experiences
    1. Martin Vogelaar, University of Groningen
    2. Peter Teuben, University of Maryland
- Your experiences
- Can we define a top 5 of skills we should learn our students?
- Should we maintain a repository of Python notebooks for astronomy education?
- Which future developments will become important?

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- Teaching astro computing:

teaching students knowledge and skills to support their practicals and introduce them to data science

- Evolution in topics and teaching methods
- The necessity – past, current, future
- Benefits of sharing views and experiences

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- Started with a course in 1997
  - Reason: skill levels varied too much amongst students
- Subjects
  - UNIX topics, command line utilities
  - Find your way on the local systems
    - network, printers, remote login
  - FITS
  - Creating reports with LaTeX
  - Plotting with SM (SuperMongo)
  - A bit of Mathematica
  - Short introductions to GIPSY, AIPS, IRAF

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- Tools
  - Local accounts (staff level)
  - Local hardware (no restrictions)
  - Involvement computer support group
  - Documentation on Internet pages
  - Oral introductions, assignments, project
- Notable
  - Every UNIX folder and most of the files were accessible to all
  - Material on Internet was copied (both ways)
  - Second year 2 ECTS (56h) course with on average 10 students

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- Big dip in 2001
  - Numerical analysis not mandatory
  - Programming not part of the curriculum
  - Attitude: students fill the gaps themselves
- After an ADASS (2000?) talk we started to introduce Python
  - Version 2.1
  - Used GNUplot for plotting (interface passing strings)
  - We trusted there would be a convergence of
    numeric, numarray, scipy-core → NumPy
  - Local stuff to read FITS files before PyFits 1.0

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- Course in 2019
  - Name: Introduction to Programming and Computational methods
  - First year, 5 ECTS (140h)
  - Documentation hosted on an intranet (prevent copies)
  - Still topics from Linux, LaTeX, FITS
  - Major part is mastering Python
  - Average between 70 and 80 students
  - Python material is astronomy focused right from the start!

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- Workflow
    - Getting to know the local environment (Linux, network, storage)
    - Introduction to tools: IPython, Jupyter Notebook, Jupyter Hub
    - Python basics
    - Packages (FITS, Plotting, numerical- and symbolic analysis)
    - Techniques (Rotation matrices, Fourier transforms, LSQ fitting)

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- Setup
  - 8 weeks course (5 ECTS=140h)
  - Short oral introductions each week
  - Practical work 3 x 3 hours a week
  - Tasks with assignments (notebooks checked by T.A.'s)
  - Midterm (written, not digital)
  - Final exam (digital)
  - Resits are projects in a notebook
- First steps using Nbgrader
- Notebooks integrated with SPHINX

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- 1. Notebook: Python for users of graphical calculators
- 2. Notebook: Python for starters
- 3. Notebook: Python sequences
- 4. Notebook: Types and conversions
- 5. Notebook: User defined functions
- 6. Notebook: Python sequences with numbers
- 7. Notebook: Simple visualization with Matplotlib
- 8. Notebook: Calculations with NumPy arrays
- 9. Notebook: NumPy arrays with random numbers, the basics
- 10. Notebook: Complex numbers
- 11. Notebook: NumPy and special numbers
- 12. Notebook: Functions (advanced)
- 13. Notebook: Object Oriented Programming basics
- 14. Notebook: Matplotlib, Object Oriented
- 15. Notebook: Matplotlib animations
- 16. Notebook: SciPy basics
- 17. Notebook: Symbolic mathematics
- 18. Notebook: Introduction to AstroPy

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- 19. Notebook: Reading data from text files
- 20. Notebook: N-dimensional data structures
- 21. Notebook: Visualization in 3 dimensions
- 22. Notebook: FITS files
- 23. Notebook: Linear Algebra
- 24. Notebook: Fourier Transforms
- 25. Notebook: Ordinary Differential Equations
- 26. Notebook: Exploring the normal distribution and Gaussian functions
- 27. Notebook: Linear Least Squares method and linear regression
- 28. Notebook: Non-Linear Least squares fitting, the basics
- 29. Notebook: Orthogonal Fitting with ODR
- 30. Notebook: Least squares fitting in the log(-log) domain

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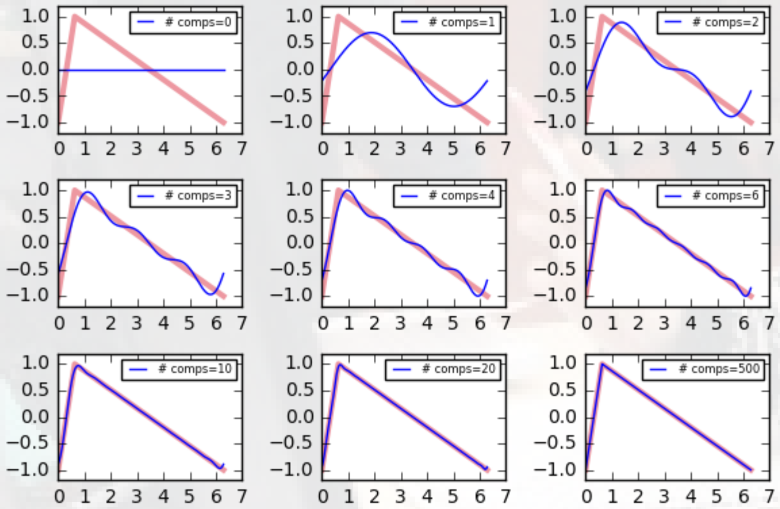
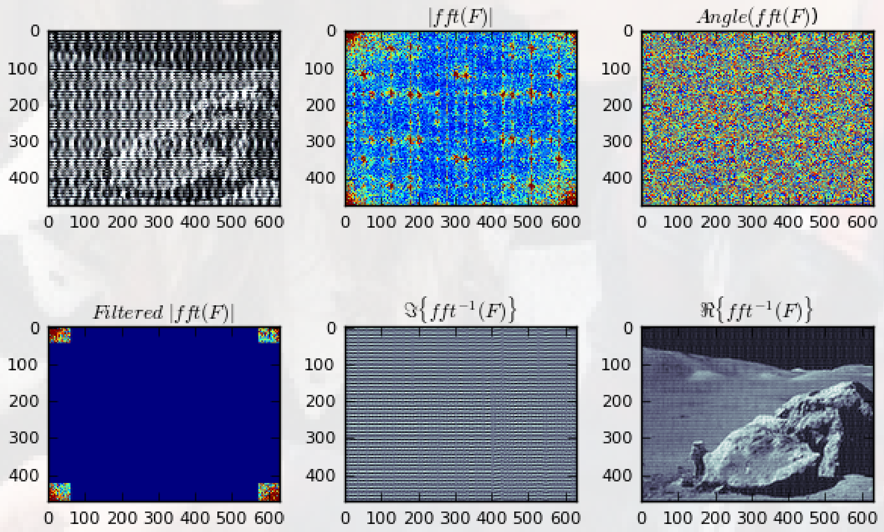
- Results
  - Improved cohesion between practical courses (at least the astronomy courses)
  - Immediate application of skills to projects of other courses (Physics lab, EM)
  - Improved understanding of concepts such as Fourier Transforms





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- Results (continued)
  - Evaluations by students are positive
  - Repository of notebooks also used by master students
  - Percentage of students want to learn C/C++ after course
  - Level of Bachelor projects has been increased

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- Some observations:
  - Expectations of staff often not realistic
  - Losing depth after adding more and more topics
  - New students are not becoming less intelligent and are not poorly educated
    - Better language skills
    - Trained in cooperative learning
    - Used to modern (cloud based) tools
  - Coordination with other courses is essential but difficult
  - Support of system management is essential
  - Education is subject to an increasingly number of rules
  - Fraction of colleagues is skeptical but their concerns seem out of date

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- Future at Kapteyn
  - Need to shift relevant computational topics to the other courses that require it
  - We will lose computer facilities for students when moving to a new building
  - Perhaps we should move earlier to platform independent solutions
    - Physics department starts to use Google Colab
  - Youth hackathon seems ideal to get the attention of high school students interested in data science.

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- Future teaching astro computing
  - Would like to see list with shared topics
  - Availability of generic Jupyter notebooks for astronomy education
  - Need to improve the link with data science