Astronomical Detector Technology and Instrumentation: Course Document, Spring 2009

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1 Course description

This course is Level M, 15 credits, held in the Spring term in Pevensey I, 2A11, Thursdays 2–5pm. It is offered to Sussex students (mainly astronomy MSc/astrophysics MPhys) and Surrey students (MSc in Radiation Detection and Instrumentation).

1.1 Aims

Specific aims are to provide students with:

1. An overview of instrumentation and detectors
2. An overview of some of the topical cutting edge questions in the field
3. An appreciation of how scientific requirements translate to instrument/detector requirements and design

1.2 Course outline

1. A crash course in Astronomy & Astrophysics (Weeks 1–2; 6hrs + Directed reading)
   (a) Fluxes, luminosities, magnitudes, etc.
   (b) Radiation processes, black bodies, spectra
   (c) Stars
   (d) Planets
   (e) Galaxies
   (f) Cosmology
2. Telescopes & Instruments (Week 3; individual student-led seminars, from reading). Examples of topics (own choice):
   (a) Optical telescopes (or some other kind of telescope, but *not* far-infrared, to avoid overlap with the project)
   (b) Interferometry
   (c) Cameras
   (d) Spectroscopy
   (e) Astronomy beyond the electromagnetic spectrum

(f) Space telescopes

3. Detectors by wavelength (Weeks 4–6; 6 hours taught & 1 hour workshop)
   (a) Gamma
   (b) X-ray
   (c) UV
   (d) Optical
   (e) NIR
   (f) Mid-IR
   (g) FIR
   (h) Sub-mm
   (i) Radio
4. Detector selection for a future space mission (Weeks 6–10; 2 hour introduction Week 6, then 4X3 hours seminars/workshops)
   (a) Scientific motivation and requirements (Week 7; group presentations in Week 8)
   (b) Detector options (Week 7 & 8; group presentations in Week 9)
   (c) External Constraints, financial, risk, etc. (Week 9)
   (d) Detector selection (Week 10)

1.3 Learning outcomes

By the end of the courses, a successful student should be able to:

- Display a basic understanding of detectors in astronomy
- Display communication skills
- Distil technological requirements from scientific drivers
- Make informed choice of detector for given application with justification

2 Reading list

Links to further resources on the Study Direct page.

2.1 Astronomy & Astrophysics

Any introductory text on astronomy, for example:

- Fundamental Astronomy, 5th edition, Karttunen et al., 2007, Hardback, Springer (ISBN-13: 978-3540341437) [or an earlier edition]
- Astrophysics: decoding the cosmos, Judith Irwin, 2007, Paperback, Wiley (ISBN-13: 978-0470013069)
- Astronomy: Principles and Practice, Roy & Clarke, 2003, Paperback, pub. Taylor & Francis (ISBN-13: 978-0750309172)

2.2 More specifically about detectors

Most astronomy books will have sections about detectors. These books provide a more extended treatment.

- Detection of Light: From the Ultraviolet to Submillimeter, 2nd edition, G. Rieke, 2003, Paperback, CUP (ISBN-13: 978-0521017107)
- Handbook of infrared astronomy, I. S. Glass, 1999, Paperback, CUP (ISBN-13:9780521633857)
- Handbook of CCD Astronomy 2nd edition, Steve B. Howell, 2006, Paperback, CUP (ISBN-13: 978-0521617628)

2.3 SPICA/SAFARI project

See Section 3.2.

- ESA Cosmic Vision documentation http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38542#
- ESA Cosmic Vision Proposal for SPICA http://sci.esa.int/science-e/www/object/doc.cfm?fobjectid=42003
- SAFARI: A FIR imaging spectrometer for SPICA (poster), Kate Isaak & Javier Goicoechea http://damir.iem.csic.es/alma2008/posters/SAFARI_SPICA_Jun08_POSTER.pdf

3 Assessments

NB: week numbers correspond to Sussex terms. Problem sets should be handed in at the start of the lecture (sheet 1) or at the end of the first hour (sheet 2); group projects should be submitted electronically via Study Direct (or by email to Anthony Smith if Study Direct doesn't work for some reason).

Type	Timing	Weighting
Coursework		100.00%
Individual Presentation (10 mins + questions)	29 Jan (Week 3)	10.00%
Problem Set (given out 15 Jan)	5 Feb, 2pm (Week 4)	10.00%
Problem Set (given out 29 Jan)	19 Feb, 3pm (Week 6)	10.00%
Group Presentation (20 mins + questions)	5 Mar (Week 8)	15.00%
Group Presentation (20 mins + questions)	12 Mar (Week 9)	20.00%
Project formative feedback deadline	26 Mar, 2pm ("Week 11")	N/A
Project report (3000–5000 words)	24 Apr, 5pm (Summer Week 1)	35.00%

Resit mode of assessment: Report (3000 words) Summer Vacation 100.00%

3.1 Individual presentations (Week 3)

Individual presentations about telescopes and instruments, on a specific topic of your choice. Assessment will be made on demonstrated understanding of a relevant area, and on presentation skills. The presentations should be 10 minutes long and will be followed by questions.

3.2 Group project

A large amount of the course will be devoted to the project, which looks at detector options for a future space mission. We will be considering the proposed SAFARI instrument on the proposed SPICA space telescope (note that SAFARI was previously known as the ESI = European SPICA Instrument). Professor Bruce Swinyard is the PI for SAFARI, and will hopefully be joining us on 26 Feb (Week 7).

The project will be a group project, in groups of 3 or 4 students (we will aim to have these groups in place by Week 3, 29 Jan). Groups should (as far as possible) have students from both Sussex and Surrey, to facilitate cross-fertilization of knowledge about astronomy and knowledge about detectors and instruments. Groups are expected to work together in preparing and delivering the presentations and in discussing aspects of the project. However, the final project reports are to be written individually.

In order to clarify what is expected for the report, your attention is drawn to the section on collusion and group work on the following page: http://www.sussex.ac.uk/academicoffice/1-4-1-2-2.html:

> **Collusion**
>
> This is when one student produces work and allows another student to copy it. If both students submit the work, BOTH students will be deemed to have colluded. Collusion falls under Academic Misconduct and can result in the piece of work being failed, a percentage reduction in the overall course mark OR an overall failure of the course.
>
> Collusion differs to **group work** - some coursework assessments will involve students working together on a particular project. Such assessments may require students sharing ideas, research and having a joint responsibility for the development of a project. Assignments for group work, however, should be written independently - identical assessments will be considered to be collusion.

3.2.1 Presentations

The two group presentations should be prepared by the group and presented by the group. In preparing for the questions at the end of the presentation, each group member should make sure they understand the content of the entire presentation.

3.2.2 Project report

Project reports (maximum 5000 words) should be written and submitted individually, with all parts of the report written by the individual student. However, groups are encouraged to share ideas in the preparation of the individual reports.

Formative feedback will be provided on draft reports submitted before the formative feedback deadline (via Study Direct, or by email to Anthony Smith). This will not be assessed, but provides an opportunity to obtain constructive feedback on the draft project report, whatever state it is in.

4 Contact details

Dr Anthony Smith (A.J.Smith@sussex.ac.uk), Pevensey II, 5A21a, 01273 (87)3094. Office hour: generally Mondays, 3-4pm, or by appointment.

Course pages:

- Study Direct: https://studydirect.sussex.ac.uk/course/view.php?id=8442
- Syllabus: http://www.sussex.ac.uk/physics/syllabus/current/26246.html