Astronomical Detector Technology and Instrumentation: Course Document, Spring 2010

Anthony Smith

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1 Course description

This course is held in the Spring term at Sussex in Pevensey II, 3A19, Thursdays 2–5pm (or via videoconference from Surrey University). It is offered to Sussex students (mainly astronomy MSc/astrophysics MPhys) and Surrey students (MSc in Radiation Detection and Instrumentation).

NB: at the time of writing, the expectation is that all students (Sussex and Surrey) will be at Sussex in person for the first two weeks, and thereafter Surrey students may attend either by videoconference from Surrey or by making their own travel arrangements to Sussex.

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; 6 hours)
   (a) Fluxes, luminosities, magnitudes, etc.
   (b) Radiation processes, black bodies, spectra
   (c) Stars
   (d) Planets
   (e) Galaxies
   (f) Cosmology
2. Telescopes & Instruments (Week 3; group presentations, 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 4–5; 6 hours)
   (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; 5 x 3 hours; general introduction in Week 6 with Prof. Bruce Swinyard)
   (a) Scientific motivation and requirements (Week 7; group presentations in Week 8)
   (b) Detector options (Weeks 7 and 9; group presentations in Week 10)
   (c) External Constraints, financial, risk, etc. (Week 9)
   (d) Detector selection (Week 9)

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 Assessments

NB: week numbers correspond to Sussex terms. Problem sets should be handed in to the relevant physics department office (Sussex or Surrey) by the deadline. Project reports 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%
Group Presentation (15 mins + questions)	28 Jan (Week 3)	10.00%
Problem Set (given out 14 Jan)	Wed 3 Feb, 4pm (Week 4)	10.00%
Problem Set (given out 28 Jan)	Wed 17 Feb, 4pm (Week 6)	10.00%
Group Presentation (15 mins + questions)	4 Mar (Week 8)	15.00%
Group Presentation (15 mins + questions)	18 Mar (Week 10)	20.00%
Project formative feedback deadline	Mon 29 Mar, 4pm	N/A
Project report (3000–5000 words)	Mon 26 Apr, 4pm	35.00%

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

2.1 Group presentations (Week 3)

Group 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 maximum 15 minutes long and will be followed by questions. The groups should be the same as for the group project: see the following section.

The 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.

2.2 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 from the Rutherford Appleton Laboratory (RAL), who is the PI (principal investigator) for SAFARI, will be joining us on 18 Feb (Week 6).

The project will be a group project, in groups of 4 or 5 students (we will aim to have these groups in place as soon as possible, and certainly by Week 2, 21 Jan). Groups are anticipated to be Sussex-only (4 + 4 + 4 = 12) or Surrey-only (4 + 4 + 4 + 5 = 17), for convenience, though this is not a strict rule. 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.

The same website also has sections on plagiarism: please read these and ensure that all sources are appropriately acknowledged in your work.

2.2.1 Presentations

As with the presentations in Week 3, the two group presentations in Weeks 8 and 10 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.

2.2.2 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 strongly 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.

3 Reading list

Links to further resources on the course web page.

3.1 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)

3.2 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)

4 Contact details

Dr Anthony Smith (A.J.Smith@sussex.ac.uk), Pevensey II, 5A22a, 01273 (87)7483. Office hour: generally Mondays, 2-3pm, or by appointment.

Course pages:

- Course page: http://astronomy.sussex.ac.uk/~anthonys/adti/
- Study Direct: https://studydirect.sussex.ac.uk/course/view.php?id=9445 (This will be used once it is clear that all the students have access to Study Direct.)
- Syllabus: http://www.sussex.ac.uk/physics/syllabus/current/26246.html