University of Glasgow | School of Physics & Astronomy

ASTRO5010: The Sun's Atmosphere

Course Information Guide

1 Course Details

Coordinator:	Dr Iain Hannah	Schedule:	Typically,2 lectures per week
SCQF Credits:	10	ECTS Credits:	5
Assessment:	Oral exams (50%) Coursework (50%)	Co-requisites:	None
Level:	Masters		
Typically Offered:	Semester 2	Prerequisites:	None

2 Course Aims

This course provides a comprehensive introduction to the physical processes at work in the solar atmosphere, and to the principles and practice of research in the physics of the solar atmosphere. It is compulsory to all students enrolled on the MSc in Astrophysics, and optional to all students on the MSc in Theoretical Physics. Its aims are:

- To develop the students' knowledge of emission processes of electromagnetic radiation; plasma physics; instrumentation; data analysis; theory and modelling – all in the context of the study of the solar atmosphere.
- To offer initial training in solar physics research which will be useful for students interested in pursuing a career in astrophysics or theoretical astrophysics.

3 Intended Learning Outcomes

By the end of the course students will be able to:

- explain how a range of observations across the electromagnetic spectrum have led to the currently accepted theories of the structure and dynamics of the solar atmosphere
- apply the equations of magnetohydrodynamics to explain the structure and dynamics of the solar atmosphere
- use basic radiation transfer theory to explain the main properties of the observed radiation, in the context of microscopic radiation processes and macroscopic radiation quantities
- recall the fundamental principles of particle acceleration and transport in the solar atmosphere and summarise their observational signatures
- formulate the main properties of the layers of the solar atmosphere (photosphere, chromosphere, transition region and corona) in the context of the structure and dynamics of both the plasma and the magnetic field
- illustrate how the sun affects space weather

- use the theories, principles and ideas presented in the course to solve a computational data-analysis or modelling problem, in the context of the study of the solar atmosphere
- summarise in a written report the theories and methods adopted to solve the computational project
- produce a critical assessment of the project outcomes in the context of published research in professional journals

4 Course Outline

- Structure and dynamics of the solar atmosphere: the solar interior and the solar atmosphere; multi-wavelengths observations; the solar cycle; solar magnetic field and its manifestations; the Sun-Heliosphere connection
- Radiation transport: microscopic radiation processes; macroscopic radiation quantities; radiation transport equation; spectral line formation; LTE and non-LTE; statistical equilibrium; frequency redistribution
- Basics of magneto-hydrodynamics: Description of the equations; ideal and resistive limits; MHD waves; dispersion relations
- Plasma physics and particle interactions: Energetic particles at the Sun; X-ray emission mechanisms/properties; Radio emission mechanisms/properties; Particle acceleration mechanisms
- The photosphere: Significance and observational issues; Size, shape, image structure; Physical structure; Sunspots and faculae; Irradiance and its variability; Stellar observations; Solar magnetism; Magnetic-field extrapolations
- From the photosphere to the corona: active regions; flux emergence; coronal holes and jets; prominences
- Solar flares and CMEs: lightcurves; links to solar cycle; morphology during impulsive and gradual phases; magnetic reconnection; energy transport and particle acceleration; flare and CME energetics; mechanisms for CMEs
- Plasma diagnostics and spectroscopy through the EM spectrum
- Space weather and solar storms: Connection of the Sun, Heliosphere and Earth

Students should note that this course provides an opportunity to develop programming skills via the computer-based project. The language of choice is Python. Other programming languages are acceptable, but the use of Python is strongly encouraged. Some resources in Python are made available on the course Moodle site.

Students with no programming skills should be prepared to learn basic programming in Python independently **as soon as possible before the start of the course**. For specific support, contact the course coordinator who may be able to provide advice and guidance.

4 Marking criteria

<u>Oral examination</u>: a mid-course oral exam of 15 minutes and an end-of-course oral exam of 15 minutes, each counting for 25% of the final grade. A list of topics will be provided at the start of the course. Students will choose one topic on which their knowledge and understanding will be assessed

in the mid-course oral exam. The examiners will choose another topic on which the students' knowledge and understanding will be assessed in the end-of-course oral exam. Students will be assessed by two examiners in each oral examination. An overall grade point is then agreed on by the two examiners using the 22-pt scale. Feedback will be emailed to students within 15 working days, before the next assessment is due. A marking sheet providing clear information about criteria used to assess the oral exams is provided on Moodle.

Project report: a marking sheet providing clear information about criteria used to assess the reports is provided on Moodle. Categories include Presentation, Structure and clarity, Insight, Answers to questions from project guide, and Appendix. Two independent markers give a primary grade for each category. An overall grade point is then awarded using the 22-pt scale by each marker. These are eventually moderated, and a single grade point is returned to students. In case of significant discrepancy, a third academic marker is called upon.

5 Further Information

Further information can be found on the course Moodle page and also using the links below:

- Course specification
- Reading list

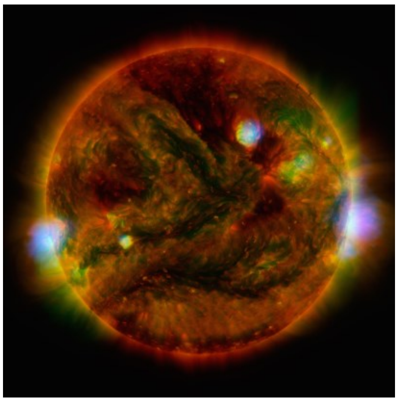

Figure 1: small explosive releases of energy in the Sun's atmosphere observed by NASA's NuSTAR telescope (courtesy Iain Hannah).