

Undergraduate Courses at the Institute of Astronomy, University of Cambridge

Part II & Part III in Astrophysics 2012 - 2013





SUMMARY

The Institute of Astronomy offers two exciting courses in Astrophysics, providing the University's only dedicated astronomy course at the Part II level and a Part III course that combines a wide choice of high level courses with the opportunity to conduct a substantial research project. (See the frequently asked questions section for a summary of other options for studying some astrophysics within other Triposes.) The philosophy behind our courses is to teach the fundamental physics that is necessary to understand the workings of the Universe on the large scale, and to illustrate its application through a range of fascinating problems in contemporary astronomy. The Part II course is taken both by those intending to proceed to Part III Astrophysics (many of whom will be considering postgraduate research in the subject) and by those who graduate after three years and who use the training in physical inference that the course provides in a range of other disciplines after graduating. (See below for further details on the destinations of Astrophysics graduates.)

The Institute of Astronomy is one of the foremost research institutions in the world and, with its setting of lawns and woodland, provides a delightful environment for undergraduate study. Students benefit from the relatively small class sizes and the friendly atmosphere of the Institute. In addition to formal participation (by elected student representatives from both Part II and Part III on the IoA Teaching Committee) students are encouraged to participate widely in the life of the Institute (such as through attendance of the weekly bread and cheese lunch and various research seminars). The free coffee and biscuits for students is particularly appreciated!

Many students find the excitement of learning astrophysics at the Institute re-invigorates their interest in science and mathematics. See below for some recent student comments on their experience of the course.

For further information please email ptastro@ast.cam.ac.uk

The choice:



Part II Astrophysics or Part II & Part III Astrophysics?

Students usually enter Part II Astrophysics on completion of Part IB in either Mathematics or Physics. Those going on to Part III Astrophysics have normally taken Part II Astrophysics. There is a possibility of changing to Part III Astrophysics from Part II Mathematics or Part II Physics. There is no restriction on entry for Part II Astrophysics, but the number of Part III places is limited to about 20 by the number of potential projects (and project supervisors) available. Preference is given to students who have taken Part II Astrophysics.

It is not necessary for students to decide on whether to apply to go on to take Part III Astrophysics at the time they begin the Part II course. However, from 2012 a II.1 in an appropriate Part II will be required for entry to Part III.

All students who proceed to Part III Astrophysics are generally required to complete at least one of the CATAM computer projects organized by the Mathematics Faculty. The computer project work may either be taken for examination credit during the year (in lieu of the extended essay) or, alternatively, completed during the long vacation following completion of Part II. A grade of at least a Beta for the project is required for admission to the Part III course.

Part II Astrophysics:



Course Content

The syllabus includes eight lecture courses split between the Michaelmas and Lent terms. These lecture courses come in two flavours: those which teach the fundamental physics underlying the rest of the course - viz, Relativity, Principles of Quantum Mechanics, Statistical Physics, Astrophysical Fluid Dynamics, and those which apply these concepts to particular astronomical subject areas viz, Topics in Astrophysics, Physical Cosmology, Stellar Dynamics and Structure of Galaxies and Structure and Evolution of Stars.

In the Michaelmas Term one of the courses (Topics in Astrophysics) plays the dual role of introducing students to a range of exciting topics in contemporary astrophysics, while developing abilities in physical reasoning and order of magnitude estimates in an astronomical context. The other courses consist of foundation courses in Relativity (at the Cavendish Laboratory), Principles of Quantum Mechanics (at the Maths Department) and Physical Cosmology at the IoA. In the Lent Term there are four courses: Astrophysical Fluid Dynamics, Stellar Dynamics and Structure of Galaxies and Structure and Evolution of Stars (at the IoA) and Statistical Physics (at the Maths Department).

The style throughout requires minimal memorising of descriptive terminology, and avoids the simple quoting and application of complicated formulae. Rather, lecturers will concentrate on the derivations of fundamentals from first principles, and the teaching of basic understanding.

There is also an examinable coursework component (comprising about 1/8 of the marks) for which students have two options: an extended essay (selected from a list of titles on contemporary research issues, announced in the Michaelmas term) or else the completion of typically two of the CATAM computer projects organised by the Mathematics Faculty, and which include astrophysical options. The projects are aimed at enabling students with a research career in mind to develop the necessary ability to solve various problems by numerical means. Note that although students may freely choose which option to take, any students proceeding to Part III Astrophysics will be required to demonstrate the necessary computing skills, normally by completing at least one CATAM computing project, before commencing Part III; thus any such students who chose the essay as examinable work will need to complete a CATAM project over the summer.

For further details please see the Part II Astrophysics Course Guide.

Part III Astrophysics

This course leads to a MSci. degree and is mainly intended as preparation for graduate studies in astrophysics, although the high level of mathematical rigour means that graduates are also highly attractive to employers in other sectors. Lecture courses are taken mainly from the wide selection of astrophysics courses taught, often by Institute of Astronomy staff, as part of the Part III Mathematics and from two courses offered in Part III Physics. Students normally take four lecture courses for examination although they often attend a wider range of lectures for interest.

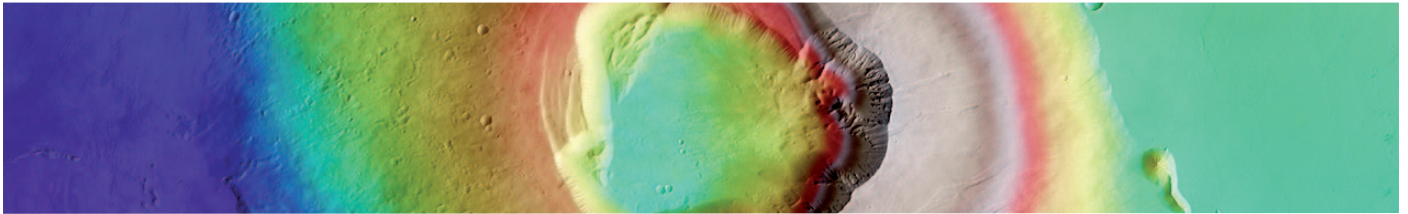


Image: Battered Tharsis Tholus volcano on Mars. Elevation data from the Digital Terrain Model (DTM) is colour coded: purple indicates the lowest lying regions and beige the highest. Credits: ESA/DLR/FU Berlin (G. Neukum)

Although most of those taking Part III Astrophysics will have taken Part II Astrophysics, the fact that most Part III Astrophysics and Part III Mathematics lectures (and examinations) are the same, means that for interested Part II Mathematics students of sufficient standard, Part III Astrophysics is an alternative to Part III Mathematics. The main difference is that Part III Astrophysics students take one less lecture course (and examination), but undertake a more substantial project, instead of the Essay. Although most of those taking Part III Astrophysics will have taken Part II Astrophysics, the fact that most Part III Astrophysics and Part III Mathematics lectures (and examinations) are the same, means that for interested Part II Mathematics students of sufficient standard, Part III Astrophysics is an alternative to Part III Mathematics. The main difference is that Part III Astrophysics students take one less lecture course (and examination), but undertake a more substantial project, instead of the Essay. It is also possible in principle, for mathematically able students who have taken Part II Physics to take Part III Astrophysics (at the discretion of their Director of Studies and of the IoA), provided they have taken the Lent Term option in Astrophysical Fluid Dynamics. Students contemplating the route from either Part II Maths or Part II Physics into Part III Astrophysics should be aware that, in the case of over-subscription, priority will be given to suitably qualified students who have done Part II Astrophysics.

Astrophysics courses currently offered in Part III Mathematics (these change from year to year) include Astrophysical Fluid Dynamics, Astrophysical Dynamics, Structure and Evolution of Stars, General Relativity, Black Holes, Cosmology and Planetary System Dynamics Galactic Astronomy and Dynamics and Origin and Evolution of Galaxies.

Further details of the courses may be found at the Faculty of Mathematics. Examinations are the same as those taken by students taking Part III Mathematics.

Part III Astrophysics students may also offer the Part III Physics courses “The Physics of the Earth as a Planet” and “Particle Astrophysics”. Further details of the courses may be found at the Department of Physics. Examinations are the same as those taken by students taking Part III Physics.

A major component of the Part III Astrophysics course is the research project (accounting for one third of the marks) which is supervised by staff at the IoA over the Michaelmas and Lent Terms. This provides undergraduates with a unique opportunity to get to the cutting edge of astronomical research and the resulting dissertation often contains work of publishable quality. Projects often either involve the analysis of astronomical data or the running of computer simulations. In addition, students develop their communications skills through giving an oral presentation on their project.

All Part II students who proceed to Part III Astrophysics, who offered an extended essay for examination in lieu of computer projects organized by the Mathematical Faculty, must submit (no later than 1 September prior to commencing Part III Astrophysics) a project of at least 8 units from a selection provided by the IoA CATAM advisor.

For further details please see the Part III Astrophysics Course Guide.

Frequently asked questions:

How mathematical is the Part II Astrophysics course - would the average physicist cope?

The Part II Astrophysics course is somewhat more mathematical than Part II Physics and thus may involve some adjustment by students from a physics background during the first term of the course. Nevertheless we find that some of our most mathematically rigorous courses are among the most popular and successful courses for students from all backgrounds.

Mathematicians and physicists entering Part II Astrophysics have different skills and have done different courses in Part IB - so how does this work?

Both mathematicians and physicists will meet both familiar and unfamiliar material. For example mathematicians may be familiar with some of the topics covered in the Astrophysical Fluid Dynamics course and physicists will likewise have met some material in the Statistical Physics course. The differences in approach of mathematics and physics students are addressed in supervisions: physicists learn greater confidence with mathematics whilst mathematicians are encouraged to develop more physically intuitive ways of looking at problems. In practice, the differences between former mathematicians and former Nat. Scis. are much less pronounced by the end of the year.

Will I learn less fundamental physics than in Part II/ Part III physics?

The key thing here is that you will learn different physics (with some overlap, of course) with the physics emphasised being that which is most relevant to astronomical rather than terrestrial contexts. Thus you'll learn considerably more dynamics but considerably less about solid state physics than in the physics course.

Do I restrict my options by doing Part II Astrophysics?

Inevitably, yes: any specialisation closes some doors and opens others. In practice this means that any student contemplating postgraduate research in another branch of physics (such as condensed matter) should remain in the Physics Tripos.



Image: disk galaxy NGC 5866 tilted nearly edge-on to our line-of-sight.
Credit: NASA, ESA, and The Hubble Heritage Team STScI/AURA

Frequently asked questions *continued*:

Are there any practicals or opportunities to use telescopes?

There is currently no practical component of the course, although we review this issue regularly in consultation with the students. The IoA however houses a number of telescopes, including the historic Northumberland and Thorrowgood telescopes, and students are encouraged to join CUAS, who provide training in the use of these telescopes as well as organising a programme of entertaining astronomical lectures.

How difficult is the Part II course?

Part II Astrophysics should not be regarded as a soft option and it is found to be challenging to mathematicians and physicists alike. On the other hand, students on average advance a class in Tripos between their Part I and Part II Astrophysics result, suggesting that the majority of students rise to this challenge. More dramatic changes in class (e.g. III -> I) are not unknown, as students are inspired by the course content and rediscover their scientific curiosity. Due to the small class size, exams are not marked to conform to a standard mark distribution which therefore varies greatly from year to year according to the enthusiasms and abilities of the student cohort.

How difficult is the Part III course?

The taught component of Part III Astrophysics derives from Part III Maths and so one should not underestimate the pace and mathematical rigour of the course. On the other hand, our selection procedure for this course means that the students who go on to Part III Astrophysics appear to be well equipped for the course, judging by their Part III results (to date the great majority have obtained 2.1s and Firsts).

Can I study astrophysics within the Mathematics and Physics Tripos?

The answer is yes in both cases. For mathematicians there are two Part II courses covering astrophysical topics (Cosmology and General Relativity), with the wide range of topics at the Part III level. Physicists take a Relativity course in the Michaelmas Term and can opt to take the IoA's Astrophysical Fluid Dynamics course as a Lent Term option (both these courses being shared with Part II Astrophysics). In Part III Physics, students may take a major option and some minor options in Part III that are astronomically related, as well as having the opportunity to do some astronomically related project work, although this is less extended than the project work component of Part III Astrophysics. The breadth and depth of astrophysical courses offered in Part III Physics is in general less than in Part III Astrophysics (or Mathematics), but, as a trade-off, students obtain a better grounding in non-astronomically related physics at the Part II level.

Can I make non-standard transitions between Mathematics and Astrophysics and Physics at the Part III level?

Maybe, but this is a matter for discussion with your Director of Studies and the departments involved. In general, transitions between Mathematics and Astrophysics at the Part II to Part III level are straightforward in either direction for qualified students. Transfers between Physics and Astrophysics after three years are now possible for suitably qualified students who have taken the Astrophysical Fluid Dynamics option in the Lent Term of Part II Physics. In addition, such students will be expected to complete a CATAM computing project over the summer. Those wishing to transfer into Astrophysics at the Part III level should note that, in the case of over-subscription, priority will be given to those coming from Part II Astrophysics. Transfers between Part II Astrophysics and Part III Physics are not encouraged.

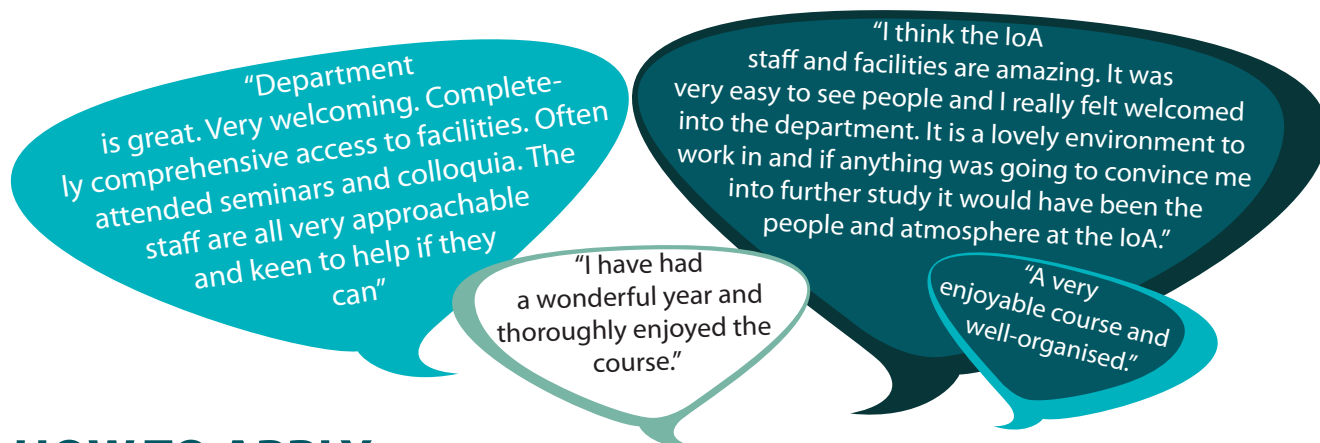
What do people do after Part II and Part III Astrophysics?

The destinations of Astrophysics graduates after Cambridge are very varied. Many have proceeded to PhDs in astronomy; in recent years, most of our students taking this path have taken the Part III Astrophysics course, which is regarded as an elite qualification by astronomy departments both in Cambridge and elsewhere in the U.K. A number of students have also gone on to acquire a range of (non astronomy related) further qualifications that build on the solid mathematical skills acquired in Part II Astrophysics. Astrophysics degrees also equip graduates for a range of non academic jobs, including teaching, software development, financial services and accountancy. Our graduates include investment bankers, business analysts, workers in the media and a vicar. In the words of an alumnus from 1996/1997 *"...having 'Astrophysics Cambridge' on one's CV certainly opens a lot of doors!"*

we end with some quotes made by our Part II students over the last decade, which we selected from many in a similarly enthusiastic vein:



...and on Part III



HOW TO APPLY

Students wishing to enrol for Part II Astrophysics only need obtain the agreement of their Director of Studies. It is helpful, however, to the Institute of Astronomy to know of your intention to take the course so we can keep you informed of the times of the introductory lectures, and arrange supervisions, etc., in good time.

Those wishing to take Part II Astrophysics and also to express in interest in Part III Astrophysics for the following year should register this request with the Institute of Astronomy. Selection of such students will take place after the Part IB results are known.

Those taking Part II Mathematics or Part II Physics who are interested in taking Part III Astrophysics in their 4th year should contact the Institute of Astronomy as early as possible to ascertain the likelihood of places being available, subject to obtaining a 2.1 in Part II. In either case, please email ptastro@ast.cam.ac.uk

Any requests for further information should be directed to Judith Moss (secretary) on Cambridge (01223) 337521 or by email to ptastro@ast.cam.ac.uk.