Astronomy 322

NON-OPTICAL ASTRONOMY

Catalog Description

Introduction to the basic techniques of radio astronomy, to the various emission mechanisms at radio wavelengths, and to radio studies of astronomical phenomena. Some discussion of other non-optical branches of astronomy, especially X-ray astronomy, but also including neutrino, cosmic ray, gravitational wave, infrared, and ultraviolet astronomy. *Prerequisites*: Astronomy 206b.

Offered in 2002-03 and alternate years.

General Description

This course surveys the methods and the results of several branches of astronomy, in particular at radio and X-ray wavelengths. Since both Froney Crawford and I are observers, we will emphasize observational techniques and results, rather than theory.

After a very brief introduction (astronomical coordinates; atmospheric opacity), we'll turn to radio astronomy, which we will study for the first 8 weeks or so.

Our study of radio astronomy will begin with some basic properties of radiation fields. This will lead us to antenna theory. Next we will take up the nature and operation of receivers at radio frequencies, and the problem of noise.

To achieve higher angular resolution—better than that realized by optical instruments—radio astronomers use interferometers. We'll study interferometers and aperture synthesis next, with special emphasis on the VLA, which I hope we have a chance to use.

Then several weeks of the course will deal with some of the discoveries of radio astronomy. We'll begin by looking at various non-thermal processes which produce radio frequency emission, then at line emission from both atoms and molecules. Along the way, I'll talk about ways in which radio astronomy has revealed the properties of a variety of astronomical sources—planets, collapsed stars like neutron stars, the interstellar medium, galaxies, quasars and the early Universe.

X-ray astronomy differs from optical and radio astronomy in many ways: each photon is precious; X-ray observations cannot be done from the ground; and optical elements are very hard to make. We'll survey X-ray techniques, look at characteristic X-ray sources in the Galaxy and beyond it, then investigate the connections between radio and X-ray astronomy. There are many, since both branches of the field are particularly useful for studying very energetic astrophysical processes. We'll spend ~4 weeks on X-ray astronomy.

In the final few weeks, we'll look more briefly at other more exotic (and more recent) branches of astronomy, such as neutrino and gravity wave astronomy. I will also ask

each of you to choose one *other* branch of non-optical astronomy, then present both a brief paper and a ~20 min. talk on it.

Reading

As is often true in advanced astronomy courses, there are no “just right” textbooks available for this course. In the first half, we will make heavy use of *An Introduction to Radio Astronomy* by B. F. Burke and F. Graham-Smith. For X-ray astronomy, we will rely on *Exploring the X-ray Universe* by Charles and Seward. Because astronomy books are so costly, I will ask you to buy only these two books. We will also occasionally use a couple of other texts and monographs. We will also read some articles from scientific journals, such as *The Astrophysical Journal*. I'll help decipher the latter. All reading material will be placed on reserve in the Observatory library.

Other Details

Given that there is no truly satisfactory textbook for 322, attendance at the lectures is important. Come to lectures prepared; do the required reading carefully and in advance. Attendance at talks given by your fellow students (see above) is mandatory.

I am trying to make arrangements to take the entire 322 class out to New Mexico to visit and to use the National Radio Astronomy Observatory’s VLA (Very Large Array). More on these hopes later.

I currently plan to give three, equally weighted, open book tests and no cumulative final (instead, the third test will be during finals week). There will also be (almost) weekly problem sets, which will be graded. Finally, I will ask each of you to do an independent project following up a branch of non-optical astronomy not covered in lecture.

For grading purposes, each of the three tests will count for 15-20%, the homework ~30%, and the independent project ~20%.

A final word on the homework—you may use any source you find useful, but you must acknowledge it (e.g.—"Problem 7 solved with help from p. 70 of J. D. Kraus's *Radio Astronomy*"). Likewise, if you work with other students, that collaboration must be acknowledged (e.g.—"John Smith actually solved most of problem 3 while I watched 'The Simpsons'"). I’ll have more to say about homework, and especially group homework projects, in an early lecture.

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