**Lecture 1: the Celestial Sphere**

1. What is this course about?
   1. Going out at night and recognizing the stars
   2. How to figure out what will be visible on a given night
   3. How to find it with your eyes, with binoculars, and with a telescope
   4. Important to understand how the sky is changing: example
   5. Reasons for these changes are the motions of the Earth and planets and the Moon
   6. Hopefully by the end of course, the stars will be your friends
   7. Sense of our motion through space:
      1. Earth and planets movement governed by laws of inertia and gravity
      2. These motions are inevitable and unstoppable by any human action.
      3. Essential lesson about physics: we are at the mercy of physical laws, which is both beautiful and frightening.
2. Practicalities:
   1. One lecture per week:
      1. Lecture material will appear in homework and exams
      2. The material will cover what is necessary for lab but also expand on that to understand the context and the physics.
      3. Much of the material is covered in the reading, but not quite all. Kaler gives a lot of great background. Edmund book is EXCELLENT tool for working outdoors with your naked eye, and has excellent concise explanation of coordinates and visibility. Another good book if you can find it which covers this material well and entertainingly is H. A. Rey's The Stars.
      4. Your lab book has a list of questions to hand in the week following each lecture (note not the final week's list).
      5. I will ask questions during lecture. Do not raise your hand and volunteer. I will go in alphabetical order. You must give an answer, even if you have to guess.
   2. One lab per week per student:
      1. Heart of this course is the lab: it will be unlike any other physics lab!
      2. Stay in your section!
      3. We will work in groups each lab; you can work with the same groups throughout the semester or switch things up as you please.
      4. We begin this week, at 7:00pm
      5. Outdoors if the weather is clear, except this first week where we will start indoors.
      6. But we ALWAYS meet in Meyer 224
      7. Later in the semester we will meet later: **why?**
      8. Be ON TIME
      9. Be PROPERLY DRESSED
      10. Have your ID
   3. One midterm in class
   4. One final
3. Basics of astronomy
   1. Here is a typical nighttime, naked-eye view of the sky
   2. What we’ll learn how to do, is connect this view of the sky to charts of the sky, or the charts in your Edmund atlas and in Peterson.
   3. Learn the constellations, the star positions, the major features like the “ecliptic” and the Galactic Plane.
   4. How the sky changes over the night and over the year
   5. And how to observe deeper with binoculars and telescopes.
   6. To begin, we will have to learn about ANGLEs.
4. Angles
   1. To begin this process, we first have to understand angle, because that is how position on the sky is defined in all of these charts
   2. Angle is fundamental in astronomy because for many things it is very hard to determine distance.
   3. Let’s recall simple geometry:
      1. There are 360 degrees in a circle. **How many degrees are in a right angle?**
      2. **How is deg broken up?** 360 deg in circle, 60 arcmin in deg, 60 arcsec in a minute
      3. hour units: 24 hours in circle, 60 minutes in hour, 60 seconds in minute
      4. 15 deg per hour, or 1 deg per 4 minutes
      5. tan(theta) = s/d
      6. small angle approximation: theta/(60 deg) = s/d
      7. a good way to estimate distance: your fist is about 10 deg: **if it just covers a person walking towards you, how far away are they?**
   4. Let’s talk about circles on a sphere:
      1. great circles: centered on center of the sphere:
         1. **Can you describe a great circle to me?**
         2. *draw and show on Celestial sphere*
      2. small circles: off-center:
         1. **Can you describe a small circle to me?**
         2. *draw and show on Celestial sphere*
5. Coordinates on the sphere:
   1. Right Ascension/Declination
      1. break up sphere using great circles: lines of longitude
      2. and small circles: lines of latitude
      3. + latitude is North, + longitude is East
      4. longitude of zero in Greenwich
      5. where are we: **do you know our longitude and latitude?**
      6. Celestial sphere has coordinates aligned with long/lat (show Celestial Sphere at this point).
      7. called: right ascension (like longitude) and declination (like latitude)
      8. Can relate positions on an image to angles.
      9. Can make, e.g., a Mercator projection map of the sky
      10. The field of view of the image is shown: **How big is the image?**
      11. or, when looking on the sky, can define North and East
      12. By convention express RA in hour, Dec in deg
      13. E.g. 11h17m30.1s +58:29:32.2 is RA=169.3754 deg, Dec=58.49228 deg
   2. Relationship between RA/Dec and L/L
      1. Show celestial sphere.
      2. At a given latitude, the direction upwards (called Zenith) is always pointing at the same declination.
      3. But the zenith points at a different right ascension as a function of time.
      4. Changes by (within a percent) one hour of angle per unit hour of time, or 15 deg per hour.
      5. By convention, at noon Universal Time (Greenwich Time) on the vernal equinox, Mar 21, the right ascension at zenith is equal to the longitude of the observer
   3. The HA/Dec coordinate system
      1. This motivates another definition of a coordinate system, which is “hour angle” and Declination.
      2. The hour angle is fixed for the observer on the surface of the Earth
      3. Due South or North is always hour angle of zero
      4. Stars rise in the East, starting with negative hour angle
      5. Their hour angles increase with time until zero, when they are highest in the sky, and are due South or due North
      6. Then they begin to set.
      7. Moment when hour angle = 0 is when the star “transits”
      8. Location of hour angle = 0 on the sky is called the “meridian”
      9. Stars on Celestial Equator visible for half their rotation (12 hours)
      10. **Are stars further North for this Northern observer visible longer or shorter than stars further south?**
      11. **Are there any stars always observable? Never?**
   4. Alt/Az coordinates
      1. A final set of coordinates.
      2. Altitude now like latitude, but measured from the horizon of observer.
      3. **What altitude is the horizon? Zenith?**
      4. Azimuth like longitude, but North is 0, East +90, South +180, West +270
      5. altitude at transit, latitude and declination are closely related:
         1. altitude at transit = (90 deg) - |declination - latitude|
         2. **What does absolute value symbol mean?**
         3. **Example: what altitude does equator transit at in NYC?**
      6. point to examples in Fig 2.5
   5. We will cover more of this in lab this week and in more detail. This material is fundamental to learning how to observe the sky so pay close attention.
   6. Next week we will begin to discuss how telescopes work.
   7. Inside cover of Edmund Atlas is worth careful study!