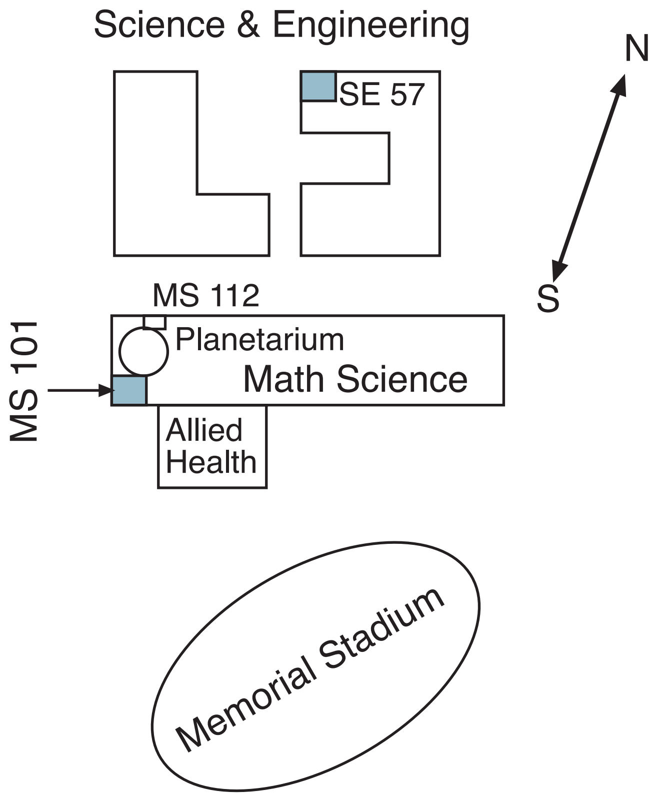
Spring semester
Instructor: Nick Strobel
Office: MS 101, 395-4526 (leave a message if I'm not there)
also: **nstrobel@bakersfieldcollege.edu**.
Department Office: SE 57, 395-4401 (another place to leave messages)
Lectures: MW 11:10 AM in the Planetarium (MS 112) for 85 minutes each
Office Hrs: TTh 12:10 – 1:40 pm in MS 101
Required Text: *Astronomy B1 Student Guide* at campus bookstore
"Opt-Req" Text: ***Astronomy Notes*** (2013 edition) at campus bookstore
Prerequisites: Reading Level 5 (college-level comprehension skill)
Recommended: First semester college algebra.
Astronomy class website:
`http://inside.bakersfieldcollege.edu` and choose the ASTR B1 link for the current semester



Course Overview:

A college-level survey of the universe, from the everyday observations we make of the sky (and what they mean) to our ideas about the inner workings (**physics**) of the planets, stars, galaxies and overall characteristics of the universe. **Equivalent to a university course** except: a) slower pace; b) instructor wants you to succeed and is much more available for questions; c) cost.

Throughout the course we will examine the process and philosophy of science from the astronomical perspective. We will use several examples from current research problems. Modern astronomy deals with some very mind-expanding stuff requiring sophisticated abstract and logical thinking so you will need to give your brain TIME to mull over and digest the concepts. If you take a look at any college astronomy textbook (not just mine) and any course outline for a college astronomy class, you will see that modern astronomy is mostly a "physics of the cosmos"—**how things work** and **how we know**. Astronomy is a visually beautiful and intellectually stimulating subject. We live in a beautiful universe on a gorgeous planet. Understanding how it became the way it is and how the parts interact with each other enriches and deepens our appreciation for the artistry around us. It is my hope that you will take the time and expend the effort to learn how our universe works.

Learning Outcomes:

At the end of the Physics of the Cosmos (Astr B1) course, the successful student **will be able to:**

1. Demonstrate a correct understanding of the cause of a given phenomenon, the physical nature of a given object, and the properties and processes of a habitable world [this is the "what we know" SLO]
2. Describe the scientific method, give the evidence for an explanation and describe the technique(s) used in determining either the property of something, how it interacts with its environment, or its origin and history [this is the "how we know" SLO]
3. Solve word problems and apply concepts to new situations not given in the book or in lecture using logical, deductive reasoning.
4. Use a computer to locate information on the internet.

Grading for day class: Your grade will be based on your performance on three exams (50 pts each) + final (100 pts), 5 required homework assignments posted on the web, 11 quizzes (8–14 pts each), 1 Skywatch (30 pts), & in-class projects – classroom participation (about 50 pts). All points will be added up and the sum divided by the maximum possible (*about* 478–480 pts total—excluding extra credit). **The course grade will be determined by the following percentage scale:**

90 – 100% = A, 80 – 89.9% = B, 65 – 79.9% = C, 50 – 64.9% = D, below 50% = F.

The *homework* assignments will stress **critical reasoning** (and some computation). Five of them will be required—see the class website for which ones they are. The required and extra credit homework will be turned in at the beginning of a Wednesday's class. Exam questions are drawn partly from the required homework assignments. Homework assignments are posted exclusively on the class website. **No late (including tardy) homework assignments will be accepted.**

Quizzes & exams are multiple-choice format. The *quizzes* will be every Wednesday except for exam weeks or Wednesday holiday. The exam material will be drawn from homework, quizzes, in-class projects, lectures, and the textbook review questions. The exams are *closed book*—no live or electronic help, except a calculator, is allowed. Dates for exams are given at the end of the syllabus and also on the class website. **There are no make-up quizzes or exams without hardcopy documentation of a medical or legal emergency from an officially-recognized neutral third party.** Any other reason, **including work schedules**, will ***not*** be accepted. You will need to do the quiz or exam make-up the week of your return. If you have another school/work activity or family event that prevents you from taking the exam or quiz on the given date, *you* will need to arrange with the instructor an alternate quiz/exam time that is **before** the given date.

The Skywatch assignment is due **May 5 (Monday)** and is worth 30 points. **No late Skywatch reports will be accepted—mark your calendar and hand it in early if you will not be able to turn it in on the due date!** Choose *one* of the Skywatch assignments described in chapters 4 and 5 of the Student Guide. The Skywatch requires a *hardcopy report* that will be turned in (or mailed or faxed) to me on campus—no emailed skywatch reports! The *hardcopy* typed, complete data *table,* star chart, and/or photos are due by **April 2 (Wednesday)** at the beginning of the class time (NOT emailed!). No late, untyped, incomplete data records accepted; hand in early if necessary! You must turn in the complete, typed data record by the due date & time and it must be COMPLETE or you will receive *zero* credit for the final report (not just the data record)! Therefore, **April 1** is the last possible date to complete your observations. If you mail me your data record or your final report, allow for at least 3 days mail transit time so that it arrives by the due date!

Your Role + Expectations:

Understanding how the universe around us became the way it is and how the parts interact with each other enriches and deepens our appreciation for the artistry around us. However, it does mean that one has to confront and leave aside misconceptions and grapple with some complex (but manageable!) ideas. This class will be challenging but I hope you will find it rewarding and worth the time it takes to learn the subject so that at the end of the semester you will have that appreciation of our universe I spoke of above.

Your role: I expect you to take responsibility for your own learning. The expectations for a college class are a definite jump up from what you had in high school! The standard for minimum acceptable work, the *quality* and amount of study time, and the pace the material is covered will be a significant jump up from high school. This a voluntary college course that meets just two times a week for 85 minutes a lecture. Because of the limited time spent in class, you will need to spend **at least** 6 hours a week *outside* of class reviewing lecture material, reading the textbook, and doing the homework assignments. You will not pass if you only attend every lecture and do just the in-lecture-period work. Your grade is determined only by *your* performance on the required assignments not on "how well I feel you did". ***It is possible in a college course to get an "F" if your performance on the required assignments is below the "D" threshold regardless of the effort you put into the course.***

- **Be prepared to learn astronomy when you come to lecture.** Conversing with your neighbor about something unrelated to the topic of the class prevents you and them from learning the concepts and makes it very difficult for other classmates to learn. Although I may not hear you conversing quietly with your neighbor, your other classmates will and they will find it hard to concentrate. Do not violate their right to an education.

  If you need to spend the time talking, doing assignments for other classes, or reading the newspaper or magazines, then do not waste your or my time by coming to lecture. **Turn OFF your cell phone in class!**
- **Take the initiative to seek clarification of the concepts.** As an adult, one needs to have the self-motivation to learn anything. I can only help you learn. I will present the material in as clear and logical way as I can and give assignments that require you to think critically about the concepts. Then it is up to you. I

expect you to ask questions when you do not understand something, either in class or in office hours or via email. If you are doing poorly and you decide not to get help, I will honor your choice. Learning is a choice and requires a voluntary decision to spend extra effort and time.

- **Use the keys at the library reserve counter.** If you answered a question on an assignment incorrectly, you will need to take the initiative to find out why your answer is incorrect. Use the keys at the library reserve counter, ask a question in class or in office hours or via email.
- **Modern astronomy deals with some very mind-expanding stuff** requiring sophisticated abstract and logical thinking so you will need to give your brain **TIME** to mull over and digest the concepts. Finding sufficient **TIME** to study the concepts and think and synthesize the concepts is the greatest stumbling block to students. Students who try to cram their studying in the day before an assignment is due get D's and F's. Modern astronomy is mostly a "physics of the cosmos"—**how things work** and **how we know**.
- If you miss a lecture, I expect you to see me after class or in my office or check the class website (or email me) to find out what you missed. **If you miss four or more classes during the semester or an exam, you *MAY* be dropped from the course. *However,*** do not assume that I will automatically do this for you. If you wish to drop, then drop via Luminis/BanWeb (`https://banweb.kccd.edu`).
- **If you are tardy, I expect you to enter quietly and sit in the BACK of the room without disturbing anyone.**
- Use the study tips in the Student Guide. They include how to more efficiently and effectively use your textbook to succeed in the class and tried-and-true techniques for taking multiple-choice exams.
- Students with disabilities who believe they may need accommodations in this class are encouraged to contact Disabled Student Programs & Services in the Student Services Building, 1st Floor, Counseling Center, 661-395-4334, as soon as possible to better ensure such accommodations are implemented in a timely fashion.

- How will you succeed at BC this semester? What determines success is not circumstance, but habit. **Habits of Mind, It's POSSIBLE at BC** has many free tools intended to help you accomplish your goals in school. Only you can overcome the challenges you face this semester and in life. Start out successfully with these steps:

  1. Visit the **Habits of Mind** website: www.bakersfieldcollege.edu/habits-of-mind .
  2. Download the app for Habits of Mind at Bakersfield College for power in your palm.
  3. Ask for help, do the work, and refuse to quit.

  Success takes energy, planning, and strategies for both the expected challenges in school as well as the unexpected twists life can take. Ask your professor for more information. Now is the time to develop new habits.

Late Assignments

Absence for an exam or quiz will result in zero credit. In the event of an unavoidable and *documented* medical or legal emergency that prevents you from taking a quiz or exam, I will consider a make-up quiz or exam on an individual basis. **Work schedules are not valid excuses.** The documentation must be from an officially-recognized neutral third party. You must take the exam or quiz the week of your return. Abuse of this policy will void your privilege of a make-up exam or quiz. It is possible to take the exam or quiz *early* in the case of medical, legal, or job conflicts. Exam and quiz dates are given on the class website. The Final Exam will be comprehensive and will be on the date given in the printed class schedule.

Required homework and skywatch assignments are due at the beginning of class on the given due date. **No late homework (including tardy!) will be accepted. No late Skywatch reports and no late, incomplete, or untyped data records accepted at all.** If you are sick, have a classmate turn it in. **Assignments, including quizzes and exams, can always be turned in *EARLY.***

I do not like people distracting their classmates by turning in something tardy after I have started instruction! *If you are tardy when a homework assignment is due, do NOT turn it in at all.* I want you to pay attention in class, not work on assignments that should be completed beforehand. Turn the assignment in the lecture before if you plan to miss class or be unavoidably late! You can also email me the homework and exam make-up assignments **but** only if they are emailed by **the beginning of class time** of the due day (not a minute or more later!!). Emailed assignments sent after the beginning of class time will simply be returned with no credit. **The emailed assignments *must* be in the BODY or your email message—no file attachments. The Skywatch report & data record canNOT be emailed.**

Absence of an in-class project (not pop quizzes, homework, or Skywatch) will result in half credit provided the work is made up within one week of the day when the project is given. Make-up of an in-class project requiring me to set something up will have to be done at a time that is convenient for *me*, the instructor. I will be lenient in the case of unavoidable and *documented* medical or legal reasons. Other miscellaneous (and missed) in-class activities that may contribute to your participation grade will be dealt with on an individual basis.

Cheating: By cheating, you are being unfair to yourself and your classmates. Cheating is defined as not doing your own work on class assignments or on exams. There is a distinction between being helped by someone and copying someone's work. State your answers to the homework and skywatch in your **own** words. Do NOT show your written (or electronic) copy of your assignment to other classmates. If you help someone out, be sure that they can articulate their response in their own words. **NO group solutions!** If copying is noticed by me, each person will get a fraction of the total group's solutions grade. Cheating on an exam will result in zero credit with no make-up possible. **Permitting someone to copy from you is just as bad.** It takes less effort to play fair than to devise clever ways of deceiving your instructor and classmates.

Exam Dates:

Exam 1: Wednesday, February 19. **Exam 2: Wednesday, March 19.**
Exam 3: Wednesday, April 23.
Final: 11:10 class = *Wednesday*, May 14 at 10 AM for 1 hr 50 min. The final is "cumulative", "comprehensive" = over the entire semester's material. Note that final exam time is one hour earlier than regular class time!

Size+Time Scales and Scientific Method
Lecture outline -- 1

Reading: ***Astronomy Notes*** sections 1.1 through 1.4 and skim chapter 2

Vocabulary terms used:
astronomical unit—average distance between the Earth and the Sun (149.6 million kilometers). Used for inter*planetary* distances. Abbreviated with "AU".
light year—distance light travels in one year (9.461 trillion kilometers, over 63,000 AU!). Used for inter*stellar* distances.

model—an abstraction that is a simplified view of reality.
theory—a logical, systematic set of principles or explanation that has undergone testing or validation from careful observations and has stood up against attempts to prove it false. A scientific theory can be used to make a variety of predictions of what will happen under different circumstances**.**

Outline

Sense of Scale
Size (solar system models: campus + quarter coin)

If Pluto orbit fits in a quarter, nearest star is how far away:___________

Milky Way galaxy is how big in this scale model: __________________

Time (cosmic calendar + walk through history)
If universe's history is put on the solar system model between the Sun and Uranus, then each big step (1 meter) would equal _________ years.

The solar system formed______ steps beyond Saturn = _____ years ago.

Life began______ steps beyond Saturn = ______ years ago.

All of human history__________________

Figuring out how things work
Observe
Generalize
Model definition
What separates a scientific theory or model from other types of explanations:__________

"Theory" in everyday language vs. a "science theory" ______________

Observe + experiment
Revise, expand, or reject the theory/model
What is the sole judge of scientific truth: ______________

Assumption #1: _____________________

Assumption #2: ____________________

"Scientific truth"— _________________

Size+Time Scales and Scientific Method
Lecture outline -- 2

Self-imposed limitation: _________________

Science – religion conflict? Not necessarily! _____________

Communicate results in clear, logical fashion & Peer Review

Value of Astronomy

Why/how astro*logy* is *not* a science

Electromagnetic Radiation (Light) + Types of Spectra
Lecture outline -- 1

Reading: sections 7.1 through 7.3 in ***Astronomy Notes***

Vocabulary terms used:

electromagnetic radiation—a form of energy made of oscillating electric and magnetic fields. It is a fancy word for "light". Includes (in order of *increasing* energy) radio, infrared, visible light (optical), ultraviolet, X-rays, gamma rays. All forms travel at *same* speed in empty space.

wavelength—the distance between two crests or two troughs of a wave.

frequency—the number of wave crests that pass a point every second. Measured in **hertz** (Hz). For electromagnetic radiation, the frequency is inversely proportional to the wavelength.

photon—a distinct "chunk" or particle of electromagnetic energy.

intensity—the *number* of waves or photons reaching your detector every second. It is *NOT* the energy of the light wave or photon.

temperature—a measure of the random motion energy of the particles in a gas, liquid, or solid.

spectrum—display of the intensity of light at different wavelengths or frequencies.

continuous spectrum—also called **thermal spectrum**—a spectrum that has energy at all wavelengths. Produced by solids, liquids, and dense (high-pressure) gases.

Wien's law—equation that relates the temperature of a thermal source to the wavelength of peak emission intensity: $\lambda_{peak} = 2.9 \times 10^6$ nanometers / temperature in Kelvin.

emission line—bright line in a spectrum that is produced by a hot, thin (low-pressure) gas. Made by an electron jumping down closer to the nucleus.

absorption line—dark line in a continuous spectrum that is produced by a cool, thin (low-pressure) gas. Made by an electron jumping up farther from the nucleus.

Outline

Electromagnetic radiation is made of _______ fields and ________ fields.
Direction of their oscillation __________; direction wave moves _________
Forms of light ________ (see definition above — memorize the order!)

Properties of electromagnetic radiation

1. Travels through __________. Why important _________
2. Speed of _____ forms of electromagnetic radiation is ____________ in empty space.
3. Definition of wavelength _________; symbol for wavelength ______

Rainbow made of ___________

Frequency = speed of wave / __________ (see definition above)

Frequency vs. wavelength

"Bluer" light: ______ wavelength, _______ frequency, ________ energy
"Redder" light: ________ wavelength, _______ frequency, ________ energy

Light as a photon

Intensity vs. energy of light _____________

Types of Spectra

Continuous (thermal) spectrum is ____________ and is produced by ____________

Thermal spectrum depends on ___________ only.

Chunk of solid lead and same-sized chunk of solid iron *at the same temperature* will have ________ spectrum.

How color depends on temperature:

very hot object has color _________, cool object has color _________

Example of Wien's law

Hotter objects are __________ and __________ than cooler objects

Spectral lines produced by __________

Emission lines produced by ___________

Absorption lines produced by ___________ and require __________ in the background.

Pattern of spectral lines depends on __________

Why the *pattern* of lines must be used and not just one line __________

Bohr Atomic Model and Doppler Effect
Lecture outline -- 1

Reading: sections 7.4 through 7.6 in ***Astronomy Notes***

Vocabulary terms used:

electron—negatively-charged subatomic particle that moves around the nucleus in specific energy levels. It has about 1800 times less mass than the proton and neutron.

proton—positively-charged subatomic particle that is found in the nucleus of an atom. It has about 1800 times more mass than its negatively-charged electron counterpart.

neutron—subatomic particle with zero charge (neutral charge) that is found in the nucleus of an atom. It is slightly more massive than the positively-charged proton.

element—a substance that cannot be decomposed by chemical means into simpler substances. All atoms of an element have the same number of protons in the nucleus.

isotope—a sub-group of an element in which the atomic nucleus has the same number of neutrons, as well as, the same number of protons. All of the atoms of an element will have very nearly the same chemical properties, but the isotopes can have very different *nuclear* properties.

ground state—the lowest energy state of an atom—all of the electrons are as close to the nucleus as possible.

doppler effect—an apparent change in the wavelength of energy produced by an object that is caused by the object's motion towards or away from the observer (along the line of sight). In astronomical spectra, the doppler effect is seen in the shifting of spectral lines.

blueshift—the shift of spectral lines from an object to shorter wavelengths because the object is moving *toward* the observer. The greater the speed of the object, the greater the blueshift will be.

redshift— the shift of spectral lines from an object to longer wavelengths because the object is moving *away from* the observer. The greater the speed of the object, the greater the redshift will be.

Outline

Bohr's model of the atom

Positively-charged particles in the nucleus ____________
Neutral particles in the nucleus ______________
Negatively-charged particles moving around the nucleus ______________
Where the negative charges can be found ______________

Every type of atom (= ______________) has ________________

Every type of atom produces __________________

Same unique pattern for all atoms of a type and laws of nature ___________________

Three basic rules of atoms:

1. Where electrons can be found _____________
2. Which energy orbits have lower energy _____________
3. Desired state of an atom ______________

Bohr Atomic Model and Doppler Effect
Lecture outline -- 2

How atoms produce emission and absorption lines

The total of ___________ + ___________ = ______________ always.

What happens to the electron when the atom *absorbs* light (photon) energy ____________

What happens to the electron when the atom *emits* light (photon) energy ___________

Big jump of electron produces spectral line of ____________ wavelength
Small electron jump produces ____________ wavelength spectral line
Photon energy = _________ – ____________

Why spectral lines of only specific wavelengths produced ____________

Why absorption lines pattern = emission lines pattern ___________

Emission line example

Absorption line example
What happens to photons with the wrong energy _________

Atom with energy levels at 3 eu, 7 eu, 8 eu can have emission lines at energies __________

Atom with energy levels at 2 eu, 10 eu, 15 eu can absorption lines at energies ___________

Doppler Effect

How wavelengths of light can be changed _____________

Direction object is moving if observer sees **blueshift** ______________
Direction object is moving if observer sees **redshift** ______________

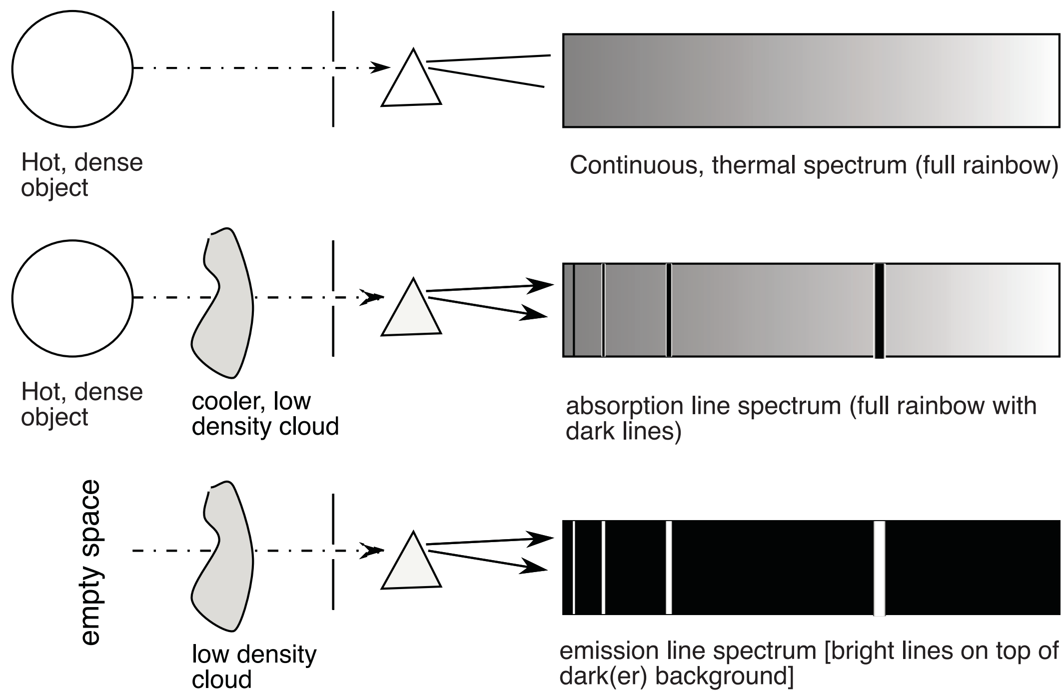
How determine speed of object __________
Greater wavelength shift means _____________

How radar guns work

Why spectral lines are used to measure doppler shifts

3.1 Types of Spectra tutorial

Courtesy of Adams, Prather, Slater, and CAPER Team



1. What type of spectrum is produced when the light emitted directly from a hot, dense object passes through a spectrometer?

2. What type of spectrum is produced when the light emitted directly from a low density cloud passes through a spectrometer?

3. Describe in detail two things: (a) the SOURCE of light and (b) the PATH the light must take from the light source to produce an absorption line spectrum.

4. There are dark lines in the absorption line spectrum that represent missing light. What happened to this light that is missing from the absorption line spectrum?

5. Stars like our Sun have cooler, low density, gaseous atmospheres surrounding their very hot, dense cores. If you were looking at the Sun's (or any star's) spectrum, which of the three types of spectra would be observed? Explain your reasoning.

6. If a star existed that was only a hot dense core and did NOT have a low density atmosphere surrounding it, what type of spectrum would you expect this particular star to produce?

7. Two students are looking at a brightly lit full moon, illuminated by reflected light from the Sun. Consider the following discussion between the two students about what the spectrum of moonlight would look like. The Moon has no atmosphere.

Student 1: *I think moonlight is just reflected sunlight, so we will see the Sun's absorption line spectrum.*

Student 2: *I disagree. An absorption line spectrum has to come from a hot dense object. Since the Moon is not a hot dense object it can't give off an absorption line spectrum.*

Do you agree or disagree with either or both of the students? Why?

8. Imagine that you are looking at two different spectra of the Sun. Spectrum #1 is obtained using a telescope that is in space far above Earth's atmosphere. Spectrum #2 is obtained using a telescope located on the surface of the Earth. Label each spectrum below as either Spectrum #1 or Spectrum #2.

Spectrum # _____

Spectrum # _____

(a) Explain the reasoning behind your choices:

(b) Would your answer change if the *space* telescope was orbiting around Pluto instead of the Earth? (There is no gas between the planets.)

Extending Our Vision — Telescopes
Lecture Outline -- 1

Reading: chapter 8 in ***Astronomy Notes***

Vocabulary terms used:

telescope—device used to gather and focus electromagnetic radiation. A telescope extends the power of human vision by making objects brighter, sharper, and larger, as well as, imaging objects in wavelengths that are not detectable by the human eye.

objective—the primary optical element of a telescope, it gathers the electromagnetic radiation and does the initial focussing.

refractor telescope—telescope that uses a large glass lens at the front end of the telescope as the objective. The objective has a maximum size limit and suffers to some degree from chromatic aberration.

chromatic aberration—a defect seen in the images from refractor telescopes that is caused by different colors of light focussing to different points behind the objective. A rainbow of colors is produced around the image.

reflector telescope—telescope that uses a large mirror at the back of the telescope as the objective. The objective has no size limit and is the type preferred for large research telescopes.

spherical aberration—a defect seen in images that is caused by the objective not being exactly shaped (e.g., an objective mirror not being exactly parabolic) so that not all of the light is focussed to the same point.

light-gathering power—the ability of a telescope to collect more light than the human eye in a given amount of time. Depends on the ***area*** of the telescope's objective, such that the larger the collecting area of the objective, the brighter the image will be.

resolving power—the ability of a telescope to detect very small details and produce sharp images. Depends on the ***diameter*** or the telescope's objective **AND** the wavelength of light used to observe, such that the more wavelengths that can be fit across the objective, the sharper the image will be.

interferometer—an array of telescopes connected electronically to act as one large telescope with much improved resolution. The resolution of the interferometer is equal to a single telescope having a diameter equal to the length of the interferometer.

magnifying power—the ability of telescope to enlarge images. Can be increased by using an eyepiece with a shorter focal length.

seeing—a measure of the amount of turbulence in the air. When the seeing is "good", the amount of turbulence is small and the images are steady (less twinkling). "Poor" seeing occurs when the atmosphere is turbulent so the images shimmer and dance around (more twinkling).

adaptive optics—a technique that compensates for atmospheric turbulence by quickly adjusting the light path in the optics. This removes seeing effects and enables the telescope to achieve much better resolution, closer to its theoretical resolving power.

Extending Our Vision — Telescopes
Lecture Outline -- 2

Outline

Two basic types of telescopes

Type of objective for refractor telescope ______________ and where at ______________
Disadvantages of refractor telescope
Cause of chromatic aberration _____________
Why refractor objectives have a maximum possible size __________

Type of objective for reflector telescope ______________ and where at ______________
Advantages of reflector telescope ________

Why they have no maximum limit on size ___________

Hubble Space Telescope
Type of telescope _____________
Problem with HST's objective ______________; result on images _____________
How the problem is corrected ______________

The need for big telescopes

How to increase the brightness of images (see faint, far-away objects) ________________
How many times brighter a star will be in a 51-cm telescope than 3-cm binoculars

How light spreads out with distance _____________

1-meter diameter telescope sees object at 1 AU, 2-meter telescopes see object at _____
3-meter telescope sees it at _________

How to increase the sharpness of images ______________ and/or _____________

What an interferometer is _______________ and why used _____________

Resolution of interferometer = _______________

Views with radio eyes (if time permits)

Why magnification is not important ____________

Atmosphere distorts our view

How atmosphere causes twinkling of stars ____________
What you see under high magnification _______________
Effect on images _____________

Why telescopes are built on tall mountains _____________
Why telescopes are put into orbit around the Earth ______________ and _____________