Everything

How does critical density relate to universe?
- Basically how much matter is there per cubic cm
- If enough, enough gravity to recollpase
- If not, Universe could go on expanding forever
- Dark energy - seals the fate of the universe and an expansive body

Accretion
- Binary star: material could fall of companion onto pair star
- doesn't fall straight in, spirals in and forms disk around the star
- accretion disk ... holding pattern until it falls into star

Milky Way size
- 100k light year across

How do we detect exosolar planets?
- same as binary stars
- direct detection: take a picture, hard because light gets swamped
- transit method: if things are lined up, exoplanet will cross in front of star and block a portion of light (very tiny)
- spectroscopic method: cross star, but doesn't block light

Everything (cont)

- star wobbles a little bit due to the gravity of the star (doppler shift)

Cosmic module principal
- the universe is the same every and in all direction (does not differ greatly anywhere)
- helps explain the structure of the universe

Brahe
- made telescope obvs to measure positions of planets

Copernicus
- first to say heliocentric

Keplar
- mathematical laws for the orbits
- used bra he's precise measurements
- ellipses and speed change as they changed distant

Galileo
- telescopic discoveries for keplar support
- TONS OF TELESCOPE OBSERVATION

Spiral structure
- spiral galaxies
- waves of higher and lower density that travel through disk
- higher density = spiral arms light up as stars form

Finding mass of a star
- in binary = easy
- in not binary = not easy

Everything (cont)

- infer in comparison to other stars

Doppler effect
- change in frequency or wavelength due to the relative motion of the source and observer

xray binary
- exist and due to transfer of energy from of one star to next, X-ray flares

Still Everything

- baryonic and non baryonic WIMPS
- baryonic suggestions are incomplete
- baryons are what we are made of (all atoms)
- non baryonic: things that are not made out of what we are made of (dark matter)
- cepheids
- stage of the stars life after the main sequence
- variable stars
- They have very particular patterns of change and variability
- luminosity is related to the period
- pulsars and neutron stars
- pulsars are neutron stars
- connected by very strong magnetic fields
- rotate very quickly

Still Everything (cont)

- if you tried to take normal stars and spin them that fast, they would pull apart
- radio waves are most common, optical light too and xray
- nova explosions and xray binary explosions
- very similar
- dump material onto surface of star = surface explosion
- young medium and old clusters when they turn off main sequence
- for the sun, 10 billion years it turns on to main sequence
- Low mass
- eject nebula, end up in white dawrf
- Galileo's experiment with velocity and acceleration
- rolled balls down a plain (demonstration in class)
- Hubble relation explain age of universe
- Several ways to think about it
- universe is expansion, hubble relation tells rate of expansion
- calculate how long ago expansion started which tells us distant
- Equilibrium in stars
- Gravitational and Hydrostatic equilibrium
- acts like a gas or a fluid

Still Everything (cont)

- Gravity tries to make the star contract
- Pressure is center is trying to slow down contraction
• Era's of the Universe
- First less than a second, particle era
- particles are being created or destroyed
- five minutes
- nucleosynthesis
- first 400k years, when universe becomes transparent
- radiation can flow freely throughout universe
- after that, stars begin to form
- cosmic microwave background
• Hubble relationship in graph form
- Velocity x Distant
- Straight line = hubble constant

Moar

• 1000 exoplanets
• Standard candle
- object who's luminosity before you measure the distant
• Greenhouse effect
- CO2 concentration in atmosphere increase, plants grow larger
- Plant grows larger, removes CO2, puts out O2 = NEGATIVE FEEDBACK
- Ice is a good reflector of sunlight, water is good absorber

Moar (cont)

- Temperature of earth rises, ice melts, less reflected and more absorbed
- warm the earth, melt more ice, make warmer = POSITIVE FEEDBACK
• Bootstrapping
- process of starting with one set of distance measurements and using it to progress
- measuring parallax using radar inside solar system by using size of earth's orbit
- once measured parallax, measure stars and clusters
• What is hubble constant?
- 70 km/sec/Mpc
- velocity for every km away from us, moving 70x that fast away from us
• Interactions of light and matter in respect to radiation
- light can scatter off of matter (blue sky)
- absorb light (photons disappear)
- produce light and photons (excite atoms in a gas)
- bend light (refraction)
• Equilibrium of stars
- amount of energy created = energy flowing out of star

Moar (cont)

- have to stay in balance or star will heat up or cool down and mess up star
• Filaments (cluster of galaxies)
- 3d spider web = filaments are lines and thread of web
- basically where galaxies and stars are heavily concentrated
• Wiens law / Greenhouse
- wavelength at which most of the radiation comes out = temperature
- our atmosphere absorbs infrared, radiation gets trapped but sun's radiation (sunlight) reaches the earth
- earth heats up because infrared is being trapped
• Dark matter evidence
- measured velocity of objects orbiting milky way
- how much mass do you need/gravity to keep object in orbit
- not enough present, has to be something else that has mass
- gravitational lensing
- light bends under influence of gravity
- gravity distorts images more than there is present, must have dark matter

Moar (cont)

- clusters of galaxies are filled with hot gas
- why doesn't it escape? moving very fast
- more gravity than should be present

Moarrr

• Dark energy existence
- universe is accelerating
- shouldn't be accelerating unless acted on by separate force
• Energy sources
- Certain labs will help explain
- Release gravitational energy to create heat
- waterfall, gravity pulls water down which creates electrical energy
- Chemical energy --> heat
- burning
- nuclear energy
- nuclear reactions to create heat or kinetic
- kinetic energy
- motion energy
- potential energy
- springs
• Motions of spiral galaxy
- motions in disk are orderly
- motions in bulge are random and spontaneous
• Measuring composition
- spectral lines
• Black holes and time

Moarrr (cont)

- all clocks slow down when nearing a black hole
- distorts time

• Black hole at the center of a galaxy
- orbit of stars
- something dark with TONS of mass at center
- no light being emitted at center

• schwarzchild radius
- radius from which light cannot escape

• Olber's paradox
- if universe is infinite in space and time, if i go out in a direction, i will eventually hit a bright star
- sky should be bright, then
- the universe is finite in time, i.e. BIG BANG

• matter vs antimatter
- antimatter exists, we see it during nuclear reaction
- counterpart to matter with opposite charges
- very limited in nature
- weird because in physics b/c antimatter and matter should be equal

• andromeda nebula?
- didn't know it was a galaxy, classified as nebulae
- hubble discovered that it was far away and as big as our Milky Way

Moarrr (cont)

• High Mass vs Low Mass
- High mass ends in supernovae explosions
- Low Mass turn into white dwarf
- Binary stars can gain matter from other stars

• CDMS lab searches
- One of the ways we look for dark matter

• Telescopes
- size goes up, collecting area goes up^2
- bigger telescope = better resolution