

Mike Clevenger: Gravitational Wave Detection

Briefly talk about the nature of gravitational waves and how they are generated, but this is another student's topic and should be only about a page or so. Focus on: What happens to an object as a gravitational wave passes through it? What were some earlier attempts to detect gravitational waves, and what resulted from these experiments? What are the current attempts (LIGO), and how does that work? (Spend at least 2 pages on LIGO). What are proposed future attempts (LISA, etc.) and how might those work? What will detection of gravitational waves tell us?

Brianna DeRobbio: Qubits

Describe the difference between a "bit" from an ordinary computer and a "qubit" from a quantum computer. What's interesting about systems of multiple qubits, as opposed to multiple bits? (You'll have to talk about entanglement a bit here; that's another student's topic.). How can qubits be stored and manipulated, in principle and in practice? What are interesting gates and manipulations that have been built so far? You might end with some big-picture stuff about future quantum computers (also another topic.)

Dominique Dizon: Radioactive Dating

Start with a short explanation of isotopes, half-life, and decay products in general. Then go through two or three different ways in which we can date objects in some detail (one should be the age of rocks and/or the Earth; another should be much shorter timescales). What are the biggest errors associated with these dating techniques, and are there ways to reduce them?

Eric Freda: Pilot-Wave Theory

Go through the (very) basics of deBroglie-Bohm theory (or sometimes just Bohmian mechanics), and how it works for a single particle in the double slit experiment. Then describe the oil droplet experiments that show similar behavior; compare and contrast. Finally, talk about what happens when Bohmian mechanics is extended to **two** particles, and how such systems do not seem to have classical analogs. (Come talk to me if this gets confusing!)

Jose Garcia: Detecting Black Holes

First describe the physics **around** a black hole; what is happening to spacetime, matter, etc. Then talk about different ways that we've been able to measure/detect black holes from earth. (Go into significant detail here; how sure are we that we're really seeing black holes?) What are some of the biggest black holes that have been found; what about the Milky Way?

Aziz Hosseini: Dark Matter vs. Dark Energy

This might be too big a topic; if you want to drop to one **or** the other, let me know which one. 1) What is the evidence for Dark Matter; detail at least several different lines of observational evidence, and the physics behind those calculations/observations. 2) What are some proposed things that Dark Matter might be? ... What is the evidence for Dark Energy, and what is the physics behind those observations? What does it do to the universe, both in the past, currently, and in the future? What are some of the proposed sources of Dark Energy? What do dark matter and dark energy imply for the history and future of the universe?

John Kam: Cherenkov Radiation

It might be good to start with a sonic boom wave for sound as an analogy; then talk about what happens when charged particles travel faster than the local speed of light in a medium. Go into significant detail, concerning interference, etc. Then talk about how this phenomenon is **used** in particle detection and maybe other applications, too.

Frederick Kuster-Tabares: Relativistic Thermodynamics

Start with a very brief summary of non-relativistic thermodynamics, and then talk about at least 2-3 major things that change when going to relativistic velocities in some detail. Also talk about what happens to the rest mass of the system. What is the predicted difference from non-relativistic thermo, and has any of it actually been observed or used in real-life scenarios? Are there any unresolved issues that come up, or significant controversy about how to apply relativity to such scenarios?

Thomas Lam: Black Holes (Basics)

This is a big topic, so try to keep it focused on the basics. A) What are they? Give equations that determine whether an object is a black hole, and show how different size black holes correspond to different average densities, different tidal effects. Perhaps go a bit into what spacetime looks like around the black hole. B) How are they created? C) What is Hawking Radiation, and how does it relate to the fate of black holes (of various sizes)? If you want to address any current research, I'd stick with the mostly-unanswered question concerning whether information is lost if it falls into a black hole; I advise you to stay away from this recent "firewall paradox".

Ryan Lichtig: Quantum Cryptography

Discuss the physics of a measurement of "polarization angle" of a photon, using a waveplate. For a given polarization angle, what values can you measure, and with what probabilities? What happens to the polarization of the photon *after* the measurement? With this background, explain a basic quantum cryptographic scheme, using polarized (not entangled!) photons to send messages. Show why the message cannot be eavesdropped upon secretly. Discuss possible insecurities in the scheme. Briefly (or not so briefly if you wish) discuss another quantum cryptographic scheme using entangled photons.

Aaron Mednick: Neutron Stars and Pulsars

What is a neutron star / pulsar, and how does it form? Try to explain the particle physics of the neutron star (what keeps it from collapsing further?), and explain in detail why it appears to "pulse". Discuss the initial discovery and continuing use of pulsars and binary pulsars -- what parameters can be measured, and what do these parameters tell us? (How many binary pulsars have been found?) What eventually happens to binary pulsars, and with what results? (Other people are doing this last topic, so no need for particular detail here.)

Carlos Morante: Particle Detectors

What were some of the earliest particle detectors? How did they work and what kind of particles did they detect? Describe how some modern detectors work -- specifically talk about detectors at large colliders; how they detect different kinds of particles, and what information they can get about them. (That section should be the largest part of the paper). Also discuss neutrino detectors and perhaps even exotic particle detectors. (but not gravity waves / gravitons)

Michael Mulanix: Quantum Chemistry

Go through several quantum phenomena that are important in chemistry; you should choose some that interest you, but definitely include the covalent bond, which you should describe in significant detail. How does quantum theory help us better understand confusing chemical phenomena, and how is it applied in practice (esp. in situations too complicated to solve exactly.) You might also talk about efforts to time-resolve/image chemical reactions, but that should be a side issue.

Myles Oldroyd: Wormholes and Closed-Timelike-Curves

Start with a general discussion of general relativity and how spacetime and matter can influence each other; frame dragging might be a relevant thing to discuss. Then try to find a simple case of a closed-timelike curve (Tipler cylinder, rotating black

hole, etc.) and discuss it in detail. Why do some physicists think that such situations are impossible (not just in practice, but in principle)? Then you perhaps can talk about more exotic solutions to general relativity (wormholes), and some related issues concerning how to keep them open, etc.

Nigel Pasman: Slowing Light

This should probably start with a discussion of phase- vs. group velocity of light, and what it means to have "dispersion". Then you'll have to get into the primary mechanism for slowing light; talk about the lasers in some detail, and see if you can make sense of a complex dielectric constant. Go into at least one experimental scenario in some detail, show what they accomplished. Is there confusion about whether the light is being "slowed" or "absorbed"? This might be an interesting controversy to explore, especially in cases where the light is stopped altogether. Are quantum effects important, or can this all be explained in terms of classical E+M?

Ilze Pukite: Macroscopic Interference

First talk about interference effects in general (for matter, not light); what are they and how can they be observed in practice. Then go through the history of how larger and larger objects have been shown to have wave-like properties; pick one or two experiments to go into in significant detail. (What were the challenges, how did they have to prepare the objects, measure the interference, etc.) End with a discussion of future and current work and what it might imply/show for quantum theory. (Here you might talk about collapse-models of quantum theory.)

Moises Quintero: Relativity in GPS

Start with an overview of the GPS system, and how relative timing is so important. Then talk about special relativistic effects; what are they, and how are they accounted for in practice? Then talk about effects due to gravity to the best that you can; the easiest one here to work out is what happens to a signal sent from one spacecraft to another as it passes closer and farther from the Earth. Which of these effects are the most important, and how are they all accounted for?

Fred Rassaii: Gravitational Lensing

First, discuss why light bends around massive objects (according to general relativity; don't go too in-depth here.) Then discuss the basic gravitational lensing geometry (a figure might be nice here). What do we typically see on Earth? What additional information does this pattern tell us? What has been learned with this technique (give an example or two). There has been exciting recent news about a supernova observed via gravitational lensing; talk about this, too!

Levi Ruiz: Quantum Computers

Distinguish between "adiabatic" quantum computers and more generic Q.C.'s that can perform operations on qubits. What sort of algorithms can a Q.C. do that a regular computer can't? Give at least one specific example, and try to explain it in rough detail. How many "qubits" would be needed for a useful Q.C.? Also talk about quantum error correction, what it is, why it's important, and (roughly) how it might be accomplished. When might a Q.C. actually be built?

Joey Spitze: LIDAR

Start with a general overview of types of remote sensing with lasers, but focus on LIDAR. What type of laser do you want for LIDAR, and why? Discuss the ideal type of laser that best fits the desired parameters, and how it works in practice. Maybe show an example of the type of data one can get with this technique, and how the laser parameters determine what type of information you can retrieve. Finally, you might want to discuss some additional feature; how one could use a "tunable laser" or phase information to get more information out of a laser-sensing system.

Ryan Sudhakaran: Sonoluminescence

Your paper should address: What is cavitation, and why is it important? What are some of the physics issues involved? On "sonoluminescence" -- explain what this effect is, and explain why it is so mysterious. Discuss the attributes (spectrum, duration, etc.) of the emitted light. Find at least two published proposals that claim to explain the effect (maybe one particular strange one...), and critique these proposals. (Compare them to each other, and discuss whether they seem plausible in light of known physical principles.)

Samuel Tanner: Antimatter Propulsion

What is the difference between matter and antimatter; why is antimatter so hard to keep around? How is it made; how is it stored? What is positronium; what are its characteristics? What happens when matter meets antimatter (in detail), and how could this be used for direct spacecraft propulsion? Why would this sort of engine be so much better than any other sort? (Give numbers...) If you want, you can look into more realistic hybrid designs (antimatter-catalyzed fusion).

Bradley Thompson: Quantum Entanglement

What are quantum-entangled particles, how are they created, and what sort of correlations can be found between them? Explain the meaning of "Bell's inequality" in this context, and what it means given that Bell's inequality is violated by experiment. (lots of bad info out there on this topic; come talk to me about it in

particular). Then perhaps discuss a basic quantum teleportation experiment that has been performed; show how the experiment is performed, explain what results occur.

Chris White: Gravitational Waves (Their nature and generation)

What are gravitational waves in general, and how can they be created? What (indirect) evidence do we have for them? (Go into the physics of binary pulsars in some detail; how the observations match the theory.) Finish the paper with a discussion of what happens when the pulsars finally merge, and (briefly) how the gravity waves from this type of event might even be detected *directly* with gravity-wave detectors. (Someone else has this last topic.)