Jan. 31—Special Relativity

Agenda

- Announce:
  - Read Ch. S3 for Thursday
- An example of Relativity crackpot
- Another way Earth could be destroyed…or what I read this weekend
- Why does one need relativity for astronomy?
- Review S2:
  - Length contraction
  - Reality of length, duration, mass
  - More tests of special relativity —Let’s unify electric/magnetic
- Lab 2
  - Error bars
  - Do we have to measure in a specific spot?
  - How do we get altitude
  - How do we get confidence interval (and why do so)

I ran across an interesting paper this weekend...

- **Phantom Energy and Cosmic Doomsday**
- Authors: Robert R. Caldwell, Marc Kamionkowski, Nevin N. Weinberg

A New Planet Found

- Name: **OGLE-2005-BLG-390Lb**
- Distance: 25,000 light years (halfway to center of Milky Way)
- So what’s so special about this planet?
A New Planet Found

- **Name:** OGLE-2005-BGL-390Lb
- **Distance:** 25,000 light years (halfway to center of Milky Way)
- **So what’s so special about this planet?**
- **Size:** about 5 times the mass of Earth!
- **Why is relativity important for this?**

- Planet found by gravitational microlensing

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Added a cool new book to list

- **Life of a planetary scientist**
- **Passion**
- Mars’ surface very old
- **Contrasts w/ Earth’s**

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Why else is Relativity (special & general) important to Astronomy?

- Effects important for observations:
  - Transverse Doppler effect
  - Gravitational red shift
  - Frame dragging effects observing (rotating) stars
- **Plays big role in death of stars**
- **GR is only relevant force for cosmology (large scale structure)**

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Understanding Length Contraction

- Measurement of length requires locating begin and end points *at the same time*
- **length can be measured w/ a ruler in your (the observer’s reference frame)**
- **Already, should be able to see that different observers will measure different lengths because no common concept of simultaneity**
Length Contraction

• Use “laser ranging” method….time how long it takes for laser to bounce off reflector
  – Stationary frame:
    • Measure the “normal length” : \( \ell_0 = \frac{c}{2t_0} \)
  – Moving frame:
    \( \ell = \frac{c}{2t} \)
• If time dilates, then length contracts

Further Thoughts on Relativity

• If you want a unique, right answer can think of
  – Proper time – time measured by a stationary observer
  – Rest length – length measured in stationary frame
  – Rest mass
• Instead of unique values for space and time, it’s a matter of perspective…
• But if that makes you uncomfortable, you can take comfort in an invariant spacetime interval

Further Thoughts on Relativity

• Special Relativity is so accepted now, that any good evidence against would upset nearly all theories
• One could say it’s taken for granted that these effects are there…here’s an example

Let’s Unify Electric and Magnetic Forces

• Consider a wire with a current running through it
• Let a charged particle fly at constant speed parallel to the wire
• We see the wire as neutral (no net charge) and the moving particle experiences a magnetic force to the wire

Let’s Unify Electric and Magnetic Forces

• That’s what we see!
• What does the moving particle see?
  – It sees the distance between positively charged particles in the wire as length contracted
  – Hence, the wire has a net charge
  – So it experiences an electric force!

Questions

• You construct a pole that is the precise length of Jackie’s (transparent) spaceship as it fuels up in port. You give it to your friend Jackie who boards her ship and flies off at constant speed. As you see her fly off, you see Jackie arrange the pole horizontally so that you can observe it. What do you see?
  1. The pole is now longer than the spaceship
  2. The pole is now shorter than the spaceship
  3. The pole is the same length as the spaceship
Questions

• Which of the following are the essential assumptions which lead to the various conclusions of special relativity?
  1. Observers may disagree about simultaneity.
  2. E=mc^2
  3. The laws of physics are the same for all observers.
  4. Time dilation occurs.
  5. Length contraction occurs.
  6. The speed of light is constant in vacuum for all observers.
  7. No material object can travel faster than the speed of light in vacuum.

Questions

• JimBob and SallyMae are each in identical spaceships with windows to look at each other. However, they cannot see stars or anything else. SallyMae sees JimBob moving and vice-a-versa for JimBob. How can we tell who is really moving?

Questions

• Larry, Moe and Curly buy identical, very accurate watches. As Larry stands still, Moe flies off westward while Curly flies off eastward, both at the same speed (relative to the ground). Moe and Curly flash their flashlights at you every minute according to their watches. Whose flashes arrive first? How often do you receive flashes?

Lab 2 Continued

Lab 3—Electric Circuits

• What are Voltage, Current, Resistance
• How to measure voltage and current
• How are voltage and current related
• Ohm’s Law
• Ok, let’s test
• Due next Tuesday (but bring what you’ve got Thursday)
Measuring Current

Measuring Voltage