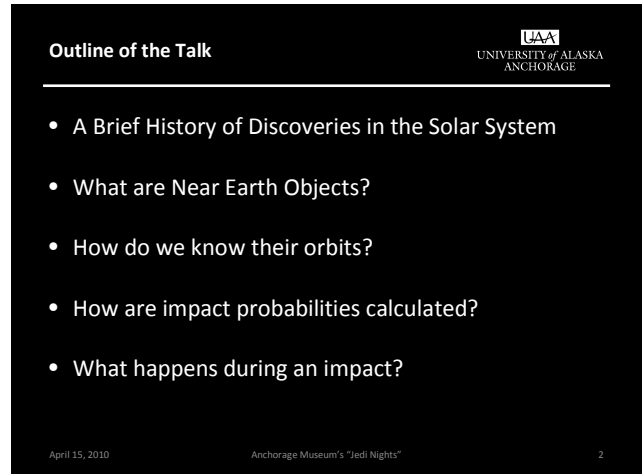

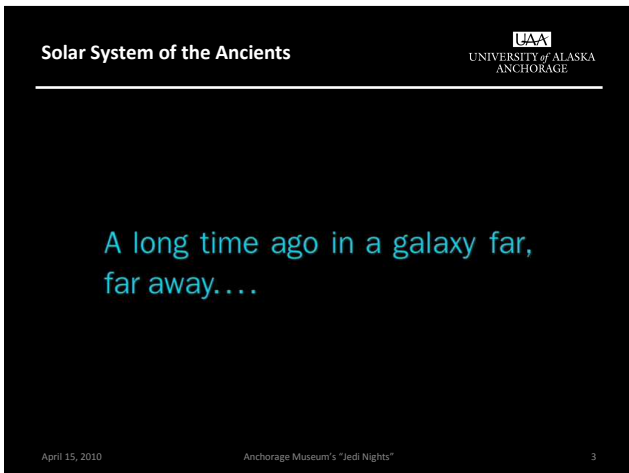
 UNIVERSITY of ALASKA ANCHORAGE
Killer Asteroids!
Separating Fact from Fiction
 (How we know what we know about the small stuff in the Solar System)
 Dr. Andy Puckett
 University of Alaska Anchorage
 Jedi Nights Lecture Series
 Anchorage Museum
 April 15, 2010




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Outline of the Talk

- A Brief History of Discoveries in the Solar System
- What are Near Earth Objects?
- How do we know their orbits?
- How are impact probabilities calculated?
- What happens during an impact?

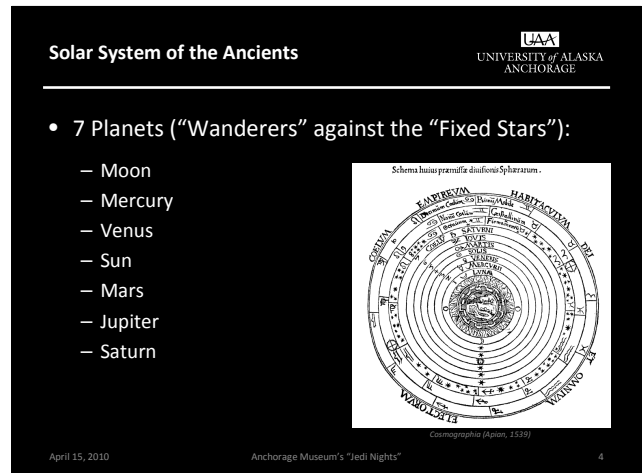
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Solar System of the Ancients

A long time ago in a galaxy far, far away...


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Solar System of the Ancients

- 7 Planets ("Wanderers" against the "Fixed Stars"):

 - Moon
 - Mercury
 - Venus
 - Sun
 - Mars
 - Jupiter
 - Saturn

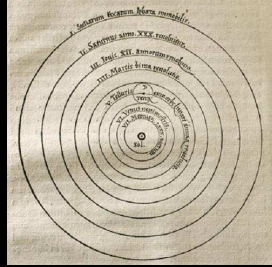


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Solar System of the Renaissance

- 6 Planets (orbiting the Sun):

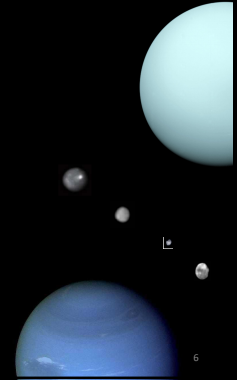
- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn



De Revolutionibus Orbium Coelestium (Copernicus, 1543)

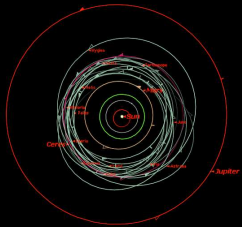
Discoveries by Telescope

- 1781 – Uranus (Planet #7)
- 1801 – Ceres (Planet #8)
 - Met expectations for a missing planet.
 - Also called "asteroid", meaning "star-like."
- 1802-1807 – 3 More Asteroids
 - Pallas, Juno, Vesta (Planets #9-11)
 - 4 planets where only 1 should be!
- 1846 – Neptune (Planet #12)
 - Uranus' orbit looked wonky.
 - Neptune found within 1° of prediction!
- 1845-1849 – 6 More Asteroids
 - Astraea, Hebe, Iris, Flora, Metis, Hygeia
 - Planets #13-18!

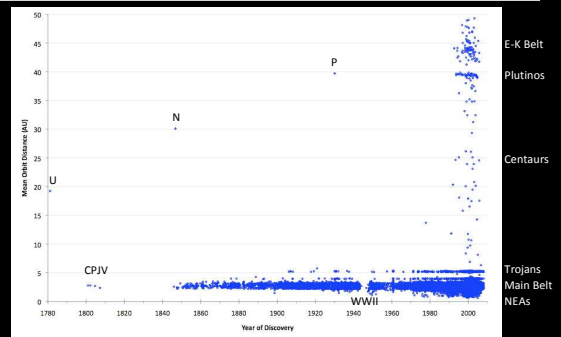


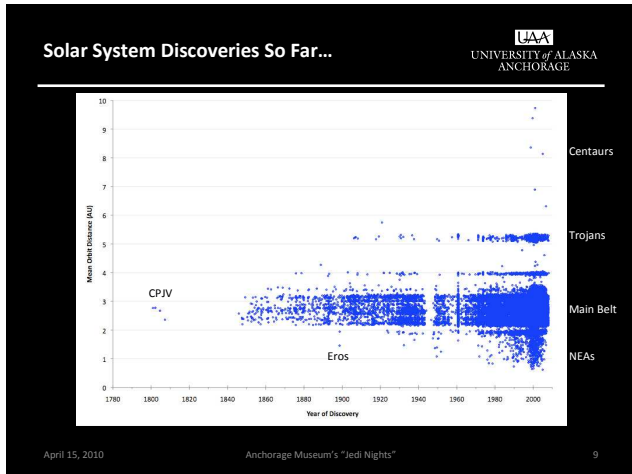
1850-1851 – Discovery of 5 More Asteroids

- Parthenope, Victoria, Egeria, Irene, & Eunomia
 - All between Mars and Jupiter.
- "This is getting ridiculous!"
- Reclassified as "asteroids" or "minor planets"
 - Widely accepted by 1854
- "Asteroids #11-15"



Solar System Discoveries So Far...





You wanna see ridiculous?

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THE MIDDLE SOLAR SYSTEM

This animation shows the motion of the middle part of the solar system over a two-year time period. The sun is at the center and the orbits of the planets Mercury, Venus, Earth, Mars and Jupiter are shown in light blue (the locations of each planet are shown as large crossed circles). Comets are shown as blue squares (numbered periodic comets are filled squares, other comets are outline squares). Main-belt minor planets are displayed as green circles, near-Earth minor planets are shown as red circles.

The individual frames were generated on an OpenVMS system, using the PGPLOT graphics library. The animation was put together on a RISC OS 4.03 system using InterGif.

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Star Wars: Fact or Fiction?

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Han: They'd be crazy to follow us, wouldn't they?

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C-3PO: The possibility of successfully navigating an asteroid field is approximately 3,270-to-1!

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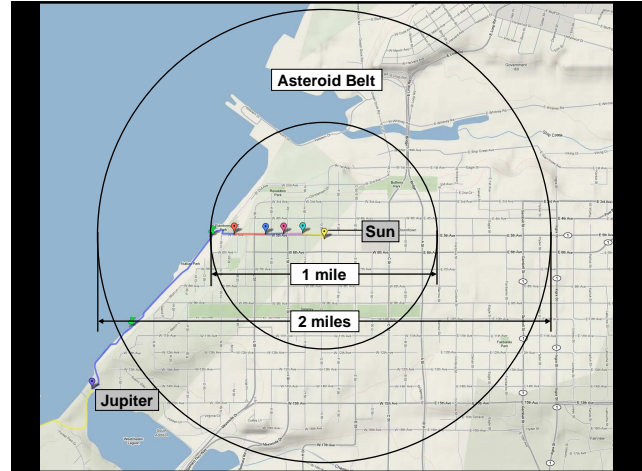
Han: Never tell me the odds.

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15





What are Near Earth Objects?

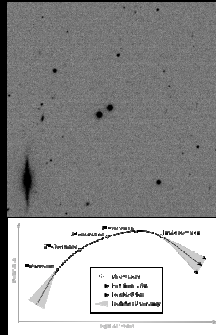
- Pass within 1.3 AU of the Sun
- First was (433) Eros, discovered in 1898.
- Currently ~6,000 NEOs known, up to 20 miles diam.

What are Potentially Hazardous Asteroids?

- PHAs are NEOs that:
 - Come w/in 0.05 AU (5,000,000 miles) of Earth's orbit, &
 - Are larger than a few hundred yards.
- There are currently 1,116 known PHAs.
- "Potential hazard" doesn't mean "definite impact"!
 - They must be watched carefully so that we can determine when "close approaches" may become "impact threats."

How do we know their orbits?

- Observations!
- We draw a curve through the observed positions at various times.
- The curve we draw must correspond to an elliptical orbit around the Sun.



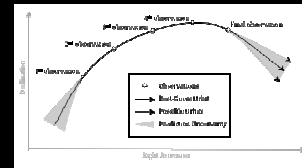
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21

How do we know their orbits?

- The orbit is only as good as the data we have!
 - Orbit quality is judged by fitting many reasonable orbits and seeing how they differ.
 - We determine the uncertainties, in both the orbital parameters and the predicted positions of the asteroid.

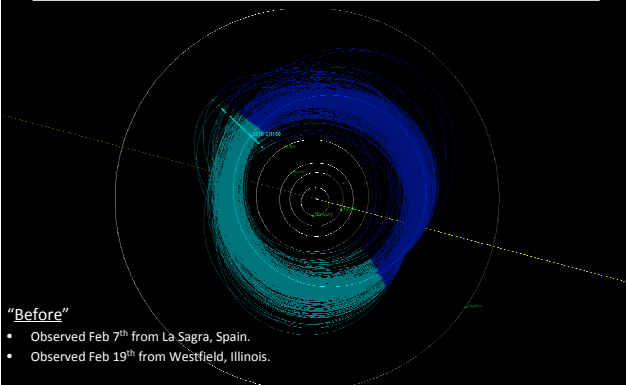


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22

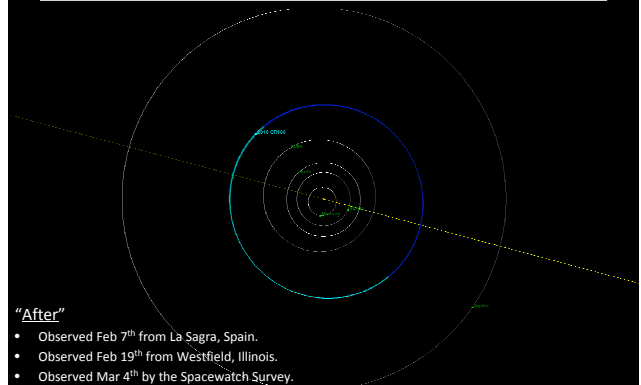
Case Study: 2010 CR₁₆₀



"Before"

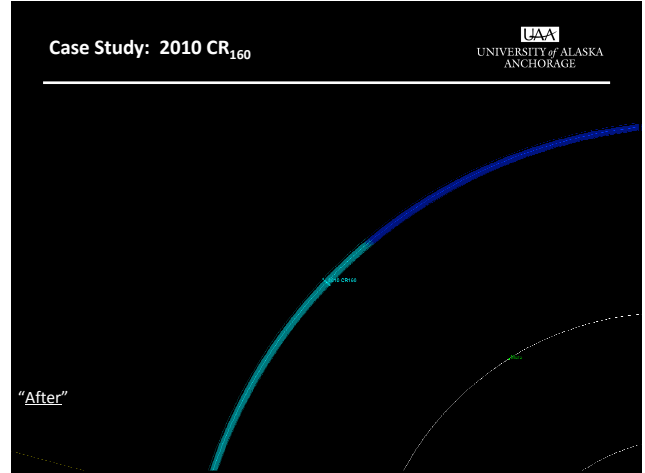
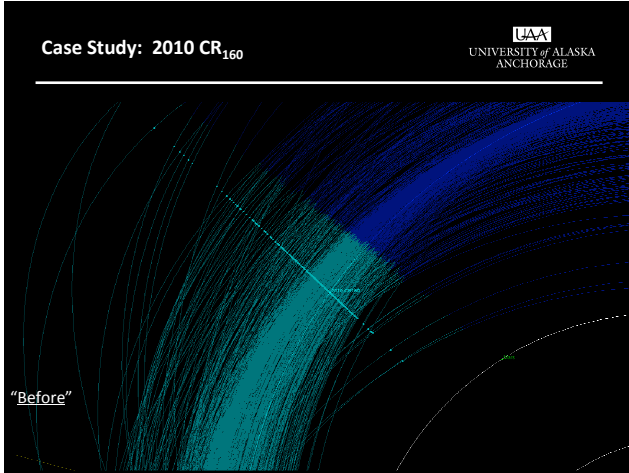
- Observed Feb 7th from La Sagra, Spain.
- Observed Feb 19th from Westfield, Illinois.

Case Study: 2010 CR₁₆₀



"After"

- Observed Feb 7th from La Sagra, Spain.
- Observed Feb 19th from Westfield, Illinois.
- Observed Mar 4th by the Spacewatch Survey.



How are Impact Probabilities Calculated?

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What happens during an impact?

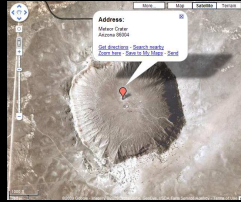
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- Possible impact speeds: 11 – 72 *km per second*
– 25,000 – 160,000 mph!
- Asteroid screeches to a halt on impact!
– Kinetic Energy is used to melt, vaporize, compress, and/or eject materials from both the asteroid & the Earth.

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What happens during an impact?

- Craters are typically 10 – 20 times larger than the impacting objects that created them.
- Meteor Crater in Arizona:
 - 1.2-km hole in the ground.
 - 70-m impactor created it.
 - (3/4 mile vs. 75 yards)



What happens during an impact?

- An asteroid with a diameter of 1 km:
 - Hits the Earth roughly every 490,000 years.
 - Collides with energy equivalent to 54 GT of TNT.
- If it hit between Eagle River & Chugiak (25km away):
 - Would create a crater reaching South Eagle River.
 - Your clothing would ignite; Buildings and bridges would be destroyed; You'd be buried in 23 feet of ejected boulders; Air blast would reach 2300 mph, blowing down 90% trees.
 - If you could run to Fairbanks, you'd be safe.

What happens during an impact?

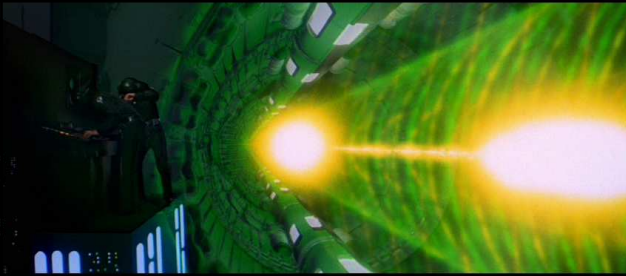
- An asteroid with a diameter of 19 km:
 - Hits the Earth roughly every 440,000,000 years.
 - Roughly what killed the dinosaurs 65,000,000 years ago.
- If it hit between Eagle River & Chugiak:
 - Talkeetna & Cooper Landing would be on crater's rim.
 - If you could run to Arizona, you'd still experience 130mph winds (Cat. 3 hurricane) and receive 1" of ejected material.
 - Impact Winter!

Star Wars: Fact or Fiction?



Episode IV: A New Hope
Alderaan

Star Wars: Fact or Fiction?

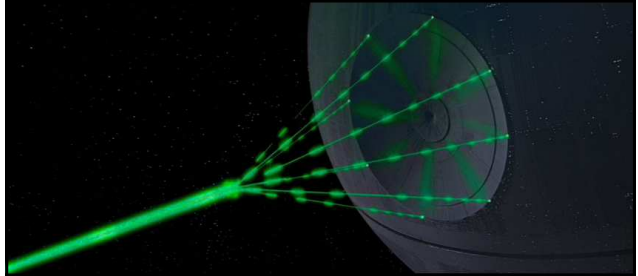


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Star Wars: Fact or Fiction?



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34

Star Wars: Fact or Fiction?



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35

Star Wars: Fact or Fiction?



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36

Star Wars: Fact or Fiction?



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37

Star Wars: Fact or Fiction?

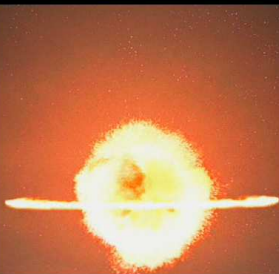


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38

Star Wars: Fact or Fiction?



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39

Star Wars: Fact or Fiction?



We've come out of hyperspace into a meteor shower.
Some kind of asteroid collision.

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Our position's correct, except... no Alderaan.
It ain't there! It's been totally blown away.

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The entire Star Fleet couldn't destroy the whole planet.
It'd take a thousand ships with more firepower than I've...

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What happens during an impact?

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- In order to shatter the Earth in this way:
 - Would need to hit it with something of roughly equal size.
 - Fortunately there are no "rogue Earths" cruising around!
 - Impact energy of 10^{14} GT of TNT.
 - That's 2,000,000,000,000 times the maximum world nuclear arsenal during the 1960s.

<http://www.lpl.arizona.edu/impacteffects/>

<http://janus.astro.umd.edu/astro/impact/>

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UAA's Planetarium & Visualization Theater

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Executive Producer
GEORGE LUCAS