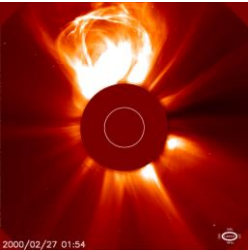


ASTR 4800 - Space Science: Practice & Policy
 Today: **How Harmful is Space Radiation?**

- **Next Class:** *The Planetary Science Decadal Survey.*
- Read the Executive Summary of Planetary Science Decadal Survey which is linked to the class website for Oct. 31.
- Interview paper due by 5 pm today.



2000/02/27 01:54

Astronomy (4800) - Space Science: Practice & Policy

1

SpaceX's Starlink and Ukraine
 Trevor Groves

- Initially 5,000 units to 25,000
- \$599 initial setup & \$110 monthly
- Requested for DOD funding has since been retracted
 - Estimated \$400 million next 12 months

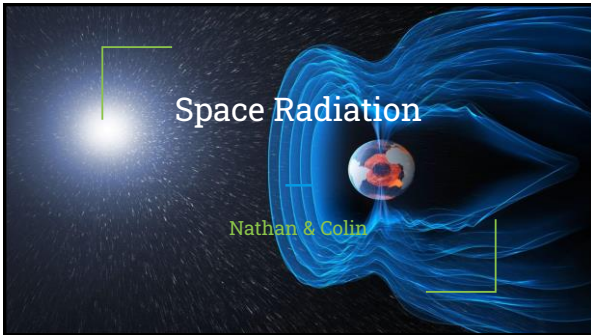



Will private space companies refrain from intentionally developing military technology for space? Will they want to?

2

Space Radiation

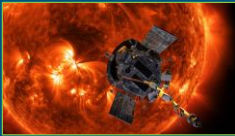

Nathan & Colin



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Outline

- Intro to radiation
- Harmful effects of radiation
- Effects on Space Travel
- Possible solutions

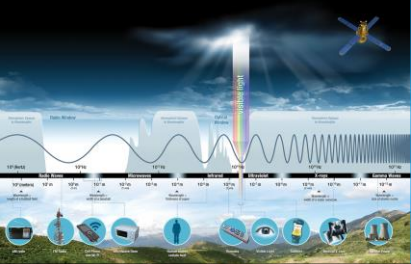
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Intro To Radiation



5

Electromagnetic Spectrum



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Ionizing and nonionizing radiation

- Ionizing
 - High Energy,
 - Causes Electrons to Separate from orbits in material it crosses
 - Alpha particles, Beta particles
- Non- Ionizing
 - Low Energy

Both cause damage!

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Types of Particles

- Alpha
 - Proton(2), Neutron(2) (helium)
- Beta
 - Fast moving particles (-)
 - Can penetrate further
- Gamma
 - High energy radiation in the form of electromagnetic waves
 - Does not give off particles

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Types/Sources of space Radiation

- Particles Trapped in Earth's Magnetic Field
- Particles Shot by the Sun
- Galactic Cosmic Rays

What source of radiation is the most predominant when going to the Moon?

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Sources of radiation- Earth's Magnetic Field

- Magnetic Field "Catches" Radiation
- Protects from Cosmic & Sun radiation
- Van Allen belts: zones of high energy particles trapped by earth's magnetic field

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Sources of radiation- The Sun

- Majority is Visible, Infrared, UV
- Solar Events (CME, Solar Flares)
 - X-rays, Gamma Rays, Protons & Electrons
 - Harmful to Astronauts + Equipment
- Varies Based on sun cycle
- Solar Maximum/ Apollo

How can we use solar min/max to our advantage in space?

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Sources Of Radiation- Galactic Cosmic Rays

- Outside solar system, within galaxy
- Dominant source of radiation
- Magnetic fields of supernova remnants
- Pass easily through skin and spaceships
- Made of Atom Fragments
 - Protons, Electrons, Nuclei

$$p = mv$$

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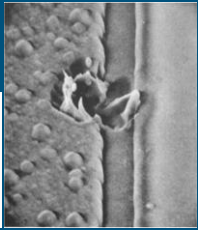
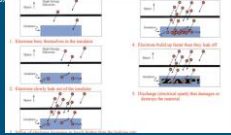
Class Discussion Question

How would you protect a Human crew to Mars over the 8 Months trip

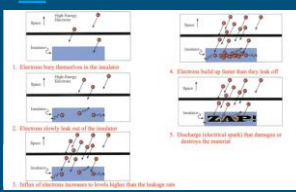
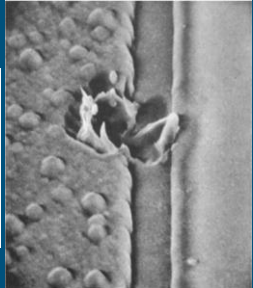
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Effects of space on electronics

- Total ionizing dose (TID) effects are the time-dependent degradation of electronics as they are continuously exposed to ionizing radiation (ionizing)
- A single event effect (SEE) usually occurs when a heavy ion deposits a charge in a device that affects its functionality
- Displacement Damage Dose (DDD) effects are structural damages imparted on the crystal lattice of the device by highly-energetic particles (non-ionizing)

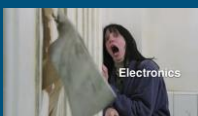

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Effects of Radiation

- Ionizing Radiation is especially bad for satellites
- Buildup of charges/ Sensitive tech
- Carrington Event (1859)
- Threat to satellites, ground stations, National security
- Radiation hardened electronics

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Humans and radiation

- 1 rad = 10 mSv
- Apollo 16/17
- 6 Months on ISS
 - 50-2000 mSv
- Uncertainties

Apollo Mission	Skid Dose, rads
7	0.16
8	16
9	20
10	48
11	18
12	58
13	24
14	1.14
15	30
16	21
17	51

Radiation exposure How does it compare?


Exposure measured in rad

- 10,000: Fatal to humans
- 6,000: Typical dosage recorded in those (mostly) workers who died within a month
- 5,000: Single dose which would kill 50% of those exposed to it within a month
- 1,000: Single dose which could cause radiation sickness, nausea, hair loss, etc.
- 400: Max radiation levels recorded in crewmembers (about 1.8 March, per hour)
- 350: Exposure of Chernobyl workers who were irradiated
- 100: Recommended limit for nuclear workers every five years
- 10: Dose in only 15 min
- 9: Airline crew (10000 per year, annual)
- 2: Natural radiation we're all exposed to, per year
- 1.02: Radiation per hour absorbed by astronauts on 12 March
- 0.4: Maximum thyroid risk
- 0.1: Hair loss
- 0.01: Mild sunburn

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Issues with Space travel

- When traveling in space we are no longer protected by the earth's atmosphere
- the proton energy is low enough from the sun that they can almost all be physically shielded by the structure of the spacecraft
- Galactic cosmic waves knock apart atoms in the material they strike, such as in the astronaut, the metal walls of a spacecraft, habitat, or vehicle, causing sub-atomic particles to shower into the structure



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Possible solutions these issues

- Increased shielding
- Hydrogen, water
- Polyethylene
- Hydrogenated boron nitride nanotubes
- "Force fields"

Why would force fields be hard to use?

