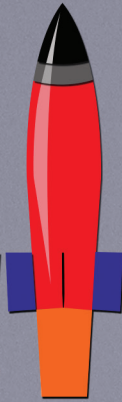
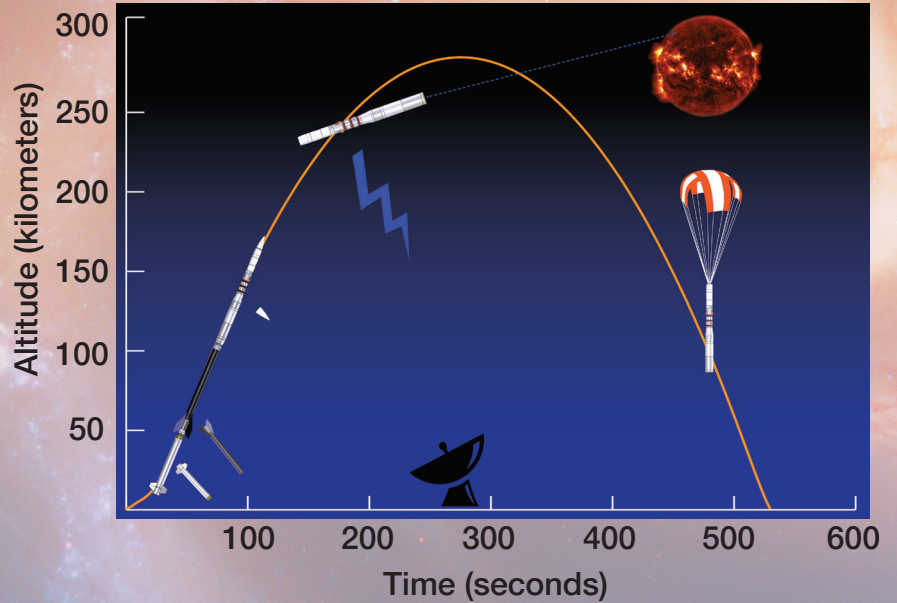


S ROCKET'S UND ING



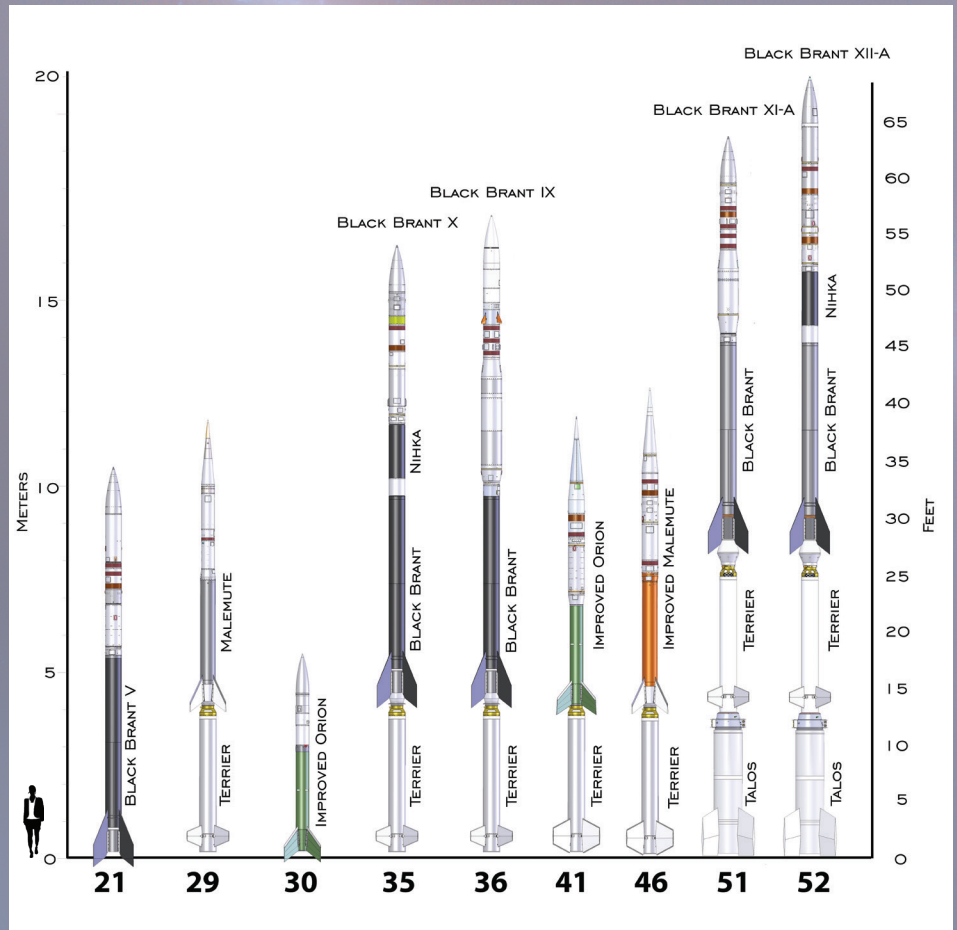
What is a Sounding Rocket?

You have probably heard about rockets that take people to space, like the Space Shuttle, that orbited around the Earth. Sounding rockets are sub-orbital, meaning that they go up, but come back to Earth a short while after taking off. They don't orbit the Earth, or fly people. Sounding rockets take their name from the nautical term "to sound", which means "to measure." NASA sounding rockets carry experiments that take scientific measurements in flight,



There are many different sounding rockets.

Sounding rockets come in many different sizes, or configurations. Some are single stage, meaning they have one rocket motor, others have two or more stages with two or more rocket motors. The largest sounding rockets have four stages.



Parts of a sounding rocket.

Nosecone

Recovery system

A parachute that brings the payload to the ground.

Guidance system

Keeps the rocket on a pre-programmed track for the first 18-seconds.

Telemetry system

Sends data back to antennas on the ground.

Scientific Experiment

Instruments to collect scientific data.

Second stage rocket motor, also called a **sustainer**.

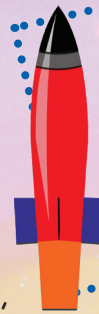
Fins

Fins are used to stabilize the rocket in flight.

What the rocket carries is called the **payload**.

This is where the scientific instruments, and other necessary technical systems are housed.

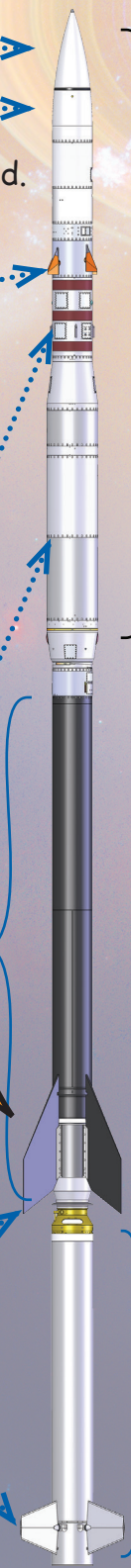
First stage rocket motor, also called a **booster**.



Did you know?

The first modern rocket was launched by Dr. Robert Goddard in 1926.

How many different words can you make from the word **ROCKET**? Each letter can only be used once.



Mission Highlight: Advanced Supersonic Parachute Inflation Research and Experiments (ASPIRE)

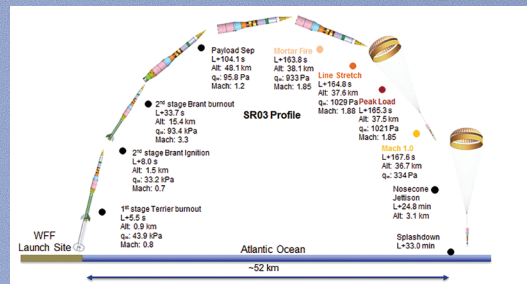
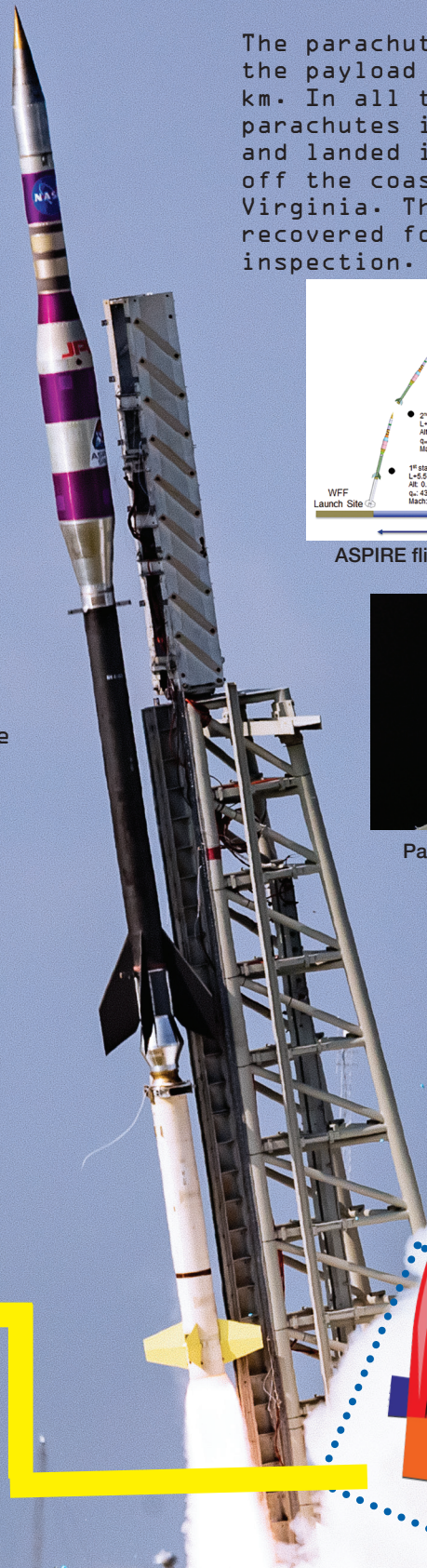
Three ASPIRE missions tested parachutes for Mars 2020 on sounding rockets.

NASA's Mars 2020 Rover will land on Mars and investigate, among other things, the potential for life on the red planet.

To test the parachute scientists need to simulate the conditions on Mars.

Mars' atmosphere is only about 1% of Earth's atmosphere. Earth's atmosphere gets thinner the higher up you go. At an altitude of about 37 km, the Earth's atmosphere has about the same density as Mars' at 10 km, the deployment altitude for the parachute. Two-stage Terrier-Black Brant V sounding rockets were used for the parachute testing.

The parachutes were deployed from the payload at an altitude of 37.5 km. In all three test flights, the parachutes inflated successfully and landed in the Atlantic Ocean, off the coast of Wallops Island, Virginia. The parachutes were recovered for post-flight inspection.



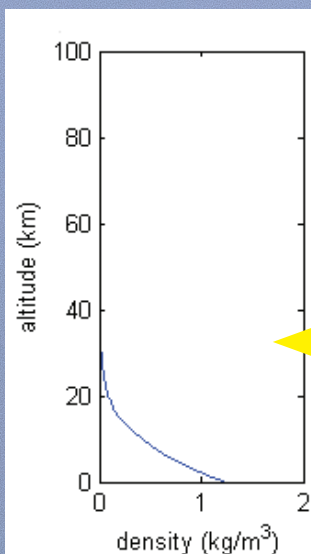
ASPIRE flight trajectory.



Parachute inflation imaged during flight.



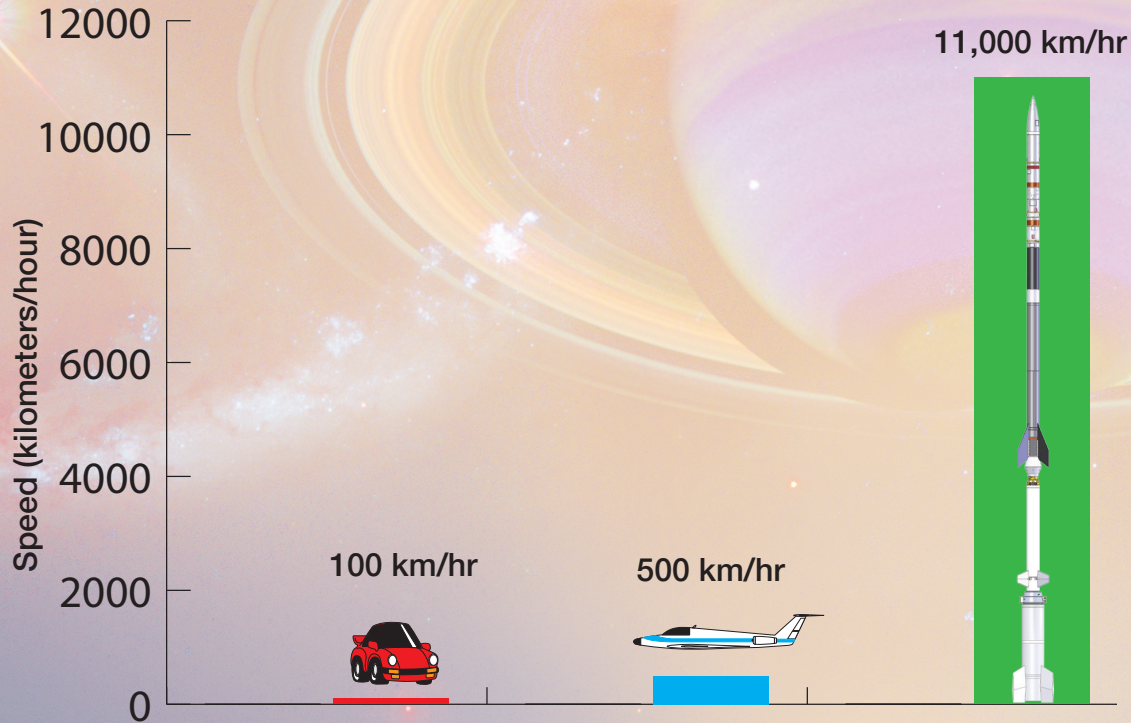
Parachute landing in the ocean.



Density of Earth's atmosphere.

Looking at the graph of density and altitude, can you formulate a relationship between the two?

How fast are sounding rockets?



One of the big, four stage, sounding rockets can reach speeds of 11,000 kilometers per hour.

What are sounding rockets used for?

Scientists that want to study space fly experiments on sounding rockets. The data is sent using radio signals, and it's almost the same as when you listen to the radio at home.

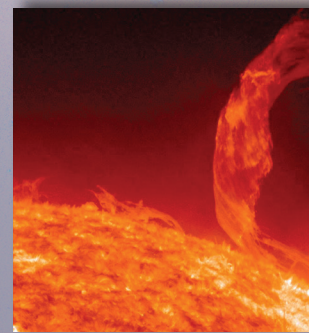
Scientists that study the northern lights, or **Aurora Borealis**, use sounding rockets. Scientists can also fly telescopes to study the Sun, other stars, planets and galaxies.



This picture shows several rockets flying to study the Aurora Borealis in Alaska.

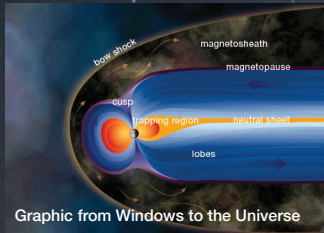


Scientists use sounding rockets to study the Sun, other stars, planets and galaxies.



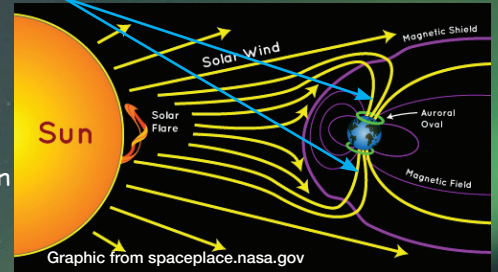
Geospace Science with Sounding Rockets

Geospace scientists study Sun-Earth connections such as effects of the Sun and solar wind on the Earth.



Sounding rockets can be used to study many interesting phenomena such as the aurora, regions of space above thunderstorms, ionospheric turbulence, noctilucent clouds, and the cusp, to name a few. They are also the only way to gather direct measurements in the region of space between roughly 40-150 km which is too high for balloons and too low for satellites.

The aurora borealis, or northern lights are created when solar storms send charged particles toward Earth. Some of the energy and small particles can travel down the magnetic field lines at the north and south poles into Earth's atmosphere. The particles then interact with the atoms of mostly oxygen and nitrogen, creating the aurora borealis and aurora australis (southern lights).

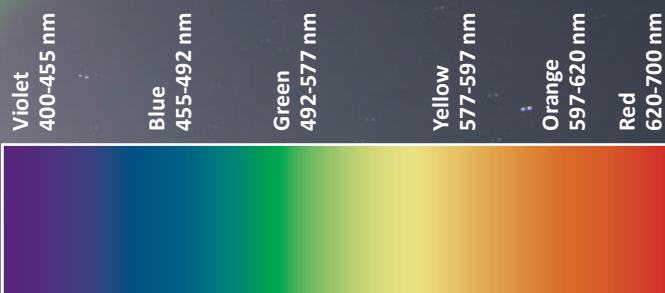


Colors of the Aurora

White light consists of many colors. To see this, use a prism to separate light into its component colors. Different colors of light have different frequencies and wavelengths. Violet light has the shortest wavelengths and highest frequencies, and red the longest and lowest.

Light, that we see as the aurora, is emitted when the solar particles interact with atoms in the atmosphere. The color of the light, and therefore the color of the aurora, is determined by which atom the particle interacts with.

Colors of white light



Violet-Blue Aurora
emitted by nitrogen
at 427.8 nm.

Green Aurora
emitted by oxygen
at 577.7 nm.

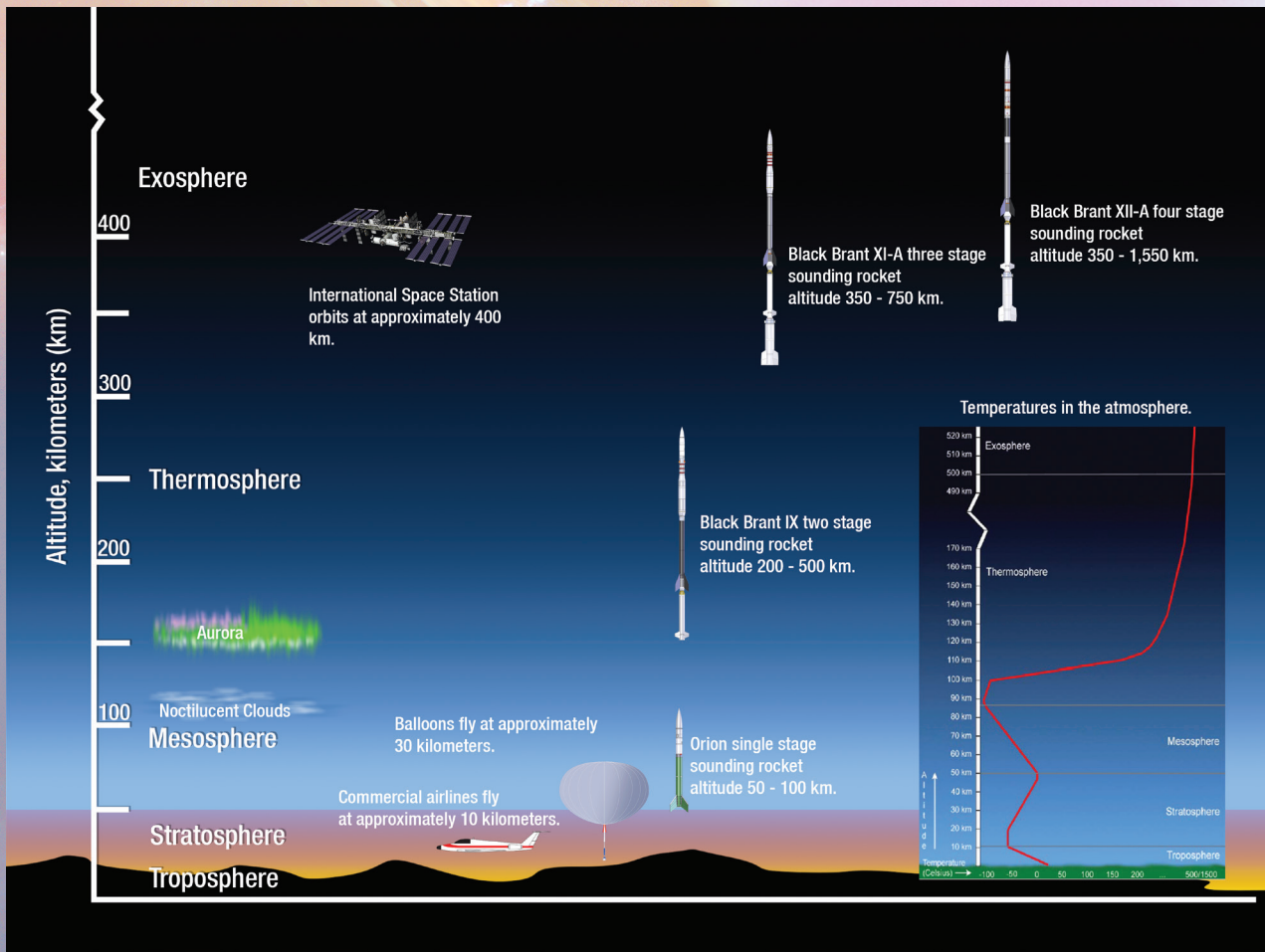
Red Aurora
emitted by oxygen
at 630 nm.

Colors of the aurora.

Sounding rockets launching from Poker Flat Research Range in Alaska to study the Aurora.

Why do you need a sounding rocket?

The Earth's atmosphere blocks most types of radiation from space from reaching the ground. To study stars, planets, galaxies, and the Sun, telescopes have to be above the atmosphere to see clearly. The Aurora Borealis occurs above 100 km and sounding rockets can fly through the Aurora to take detailed measurements.



This picture shows the layers of the atmosphere. Based on the descriptions below, can you identify the correct layer? Note! The descriptions are not in order.

In the Earth's _____, the air is relatively mixed together and the temperature decreases with altitude.

Ozone is concentrated in the _____ around an altitude of 25 kilometers.

Atoms and molecules escape into space in the _____, the highest layer of the atmosphere.

The _____ is the lowest layer of the Earth's atmosphere.

The air is really thin in the _____. Temperatures in this layer start out very cold, but can increase up to 1,500 degrees Celsius.

Word search

Find these words in the chart:

AURORA
BOOSTER
ENGINEER
GALAXY
PAYLOAD
PLANETS
ROCKET
SCIENTIST
SOUNDING
STARS
SUSTAINER

T K C C S G I R N J P S U W L
I E A E A S E R Y X C Q H P A
H O C L L T Z D E I D T B G A
G I A H S V L Z E E E O B D U
F X G O N T G N I D N U O S R
Y R O B S I T I A X S I L N O
O B O D K I C W C D U S G A R
D K G C S V Y I M V S R O N A
A F Z T K P B A A W T C A X E
O P L A N E T S C N A A C U N
L S R A T S T U U W I Z I O P
Y X S F L F L I K P N T G J Y
A I A X A C U J M N E L A A U
P H Q U Q H H G E F R I Z X K
O X K N Z V P N H Y Z E E D O

Have rocket, will travel!

Sounding rockets are launched all over the world. NASA Goddard Space Flight Center's Wallops Flight Facility is the home base for sounding rockets, but the rockets and all of the things needed to launch them can be transported to other places. Launchers, ground stations, telemetry antennas, everything needed to support a launch is packed up and shipped to locations where the scientists want to collect data. A good example of this is when scientists want to study the Aurora Borealis. The Aurora is not reliably visible from Wallops, and teams have to travel to places like Alaska, Norway, and Sweden to launch rockets to study the Northern Lights.



Green dots on the map show where sounding rockets are often launched from (active launch sites), white dots are less often used launch sites (inactive launch sites).

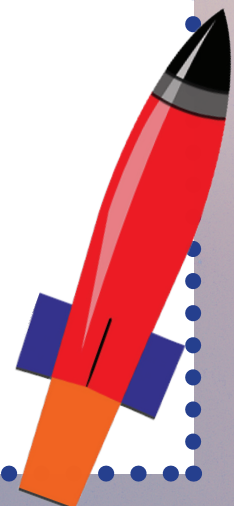
Active launch sites:

- 1 - Wallops Flight Facility, Virginia - Home of Sounding Rockets
- 2 - White Sands Missile Range, New Mexico
- 3 - Poker Flat Research Range, Fairbanks, Alaska
- 4 - Norway: two launch sites, Andoya Space Center and Svalbard
- 5 - Esrange, Kiruna, Sweden
- 6 - Kwajalein Atoll, Marshall Islands
- 7 - Australia: several launch sites
- 8 - Barking Sands, Hawaii

Inactive launch sites:

- 9 - Greenland (Søndre Strømfjord, Thule)
- 10 - Fort Churchill, Canada
- 11 - Camp Tortuguero, Puerto Rico
- 12 - Alcantara, Brazil
- 13 - Punta Lobos, Peru

Fill out the missing launch site numbers on the map.

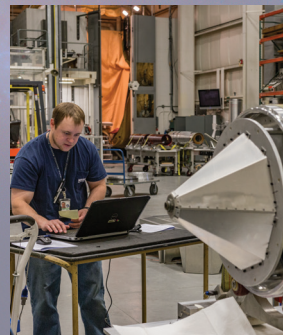


Teams of people work with sounding rockets

Every sounding rocket project has many people with different skills working together. There are **engineers** who design the payload, **technicians** who build it, **scientists** with the experiments, people that control the launch, **managers** and **administrators** who make sure everything stays on schedule.



Teams of scientists create instruments to fly on sounding rockets.



Engineers, technicians, machinists and managers fabricate, test and launch the missions.



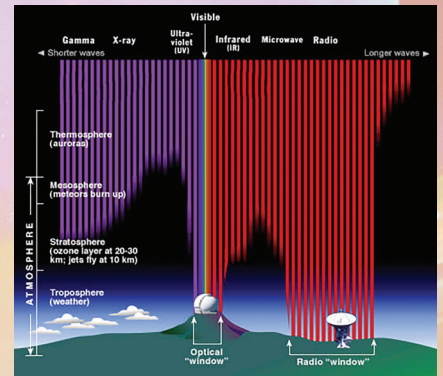
Studying the Sun and Other Stars

Adapted from: How Astronomers Use Spectra to Learn About the Sun and Other Stars, by Dr. Jeffrey Brosius. NASA Grant NAG5-11757. To download complete guide, visit: https://sunearthday.nasa.gov/2006/materials/spectrabook_ver2.pdf

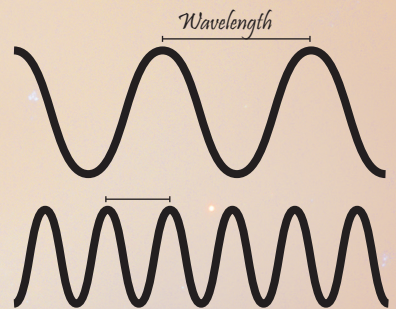
How do astronomers discover secrets about the Sun, stars and other objects in space that are so far away that no spacecraft from Earth has ever been there? The answer is, by studying the light that all of these objects emit. Light is part of the electromagnetic spectrum -- and the light humans see is only a very small part of that. This spectrum encompasses all forms of radiation - energy that moves through space. The term "visible light" refers to the part of the spectrum we can see. Light carries a lot of information. It tells us not only that various objects exist and how bright they are, but also what they are made of (their composition), how hot they are, how dense they are, how they are moving, and how strong their magnetic fields are.

The Sun and other stars emit a continuous spectrum (meaning all the colors of visible light). They also emit radio, microwaves, infrared light, ultraviolet light, X-rays, and/or gamma rays. Most of these wavelengths are absorbed by the Earth's atmosphere. Sounding rockets are used to launch telescopes above the atmosphere to study wavelengths that are absorbed by air.

Like everything on Earth, the Sun, stars, and other objects out in space are made of atoms. An atom is the smallest unit that can be identified as any particular element (like hydrogen, helium, carbon, nitrogen, oxygen, iron, and so on). Since there are about 100 different elements, there are also about 100 different kinds of atoms. Each different type of atom or ion emits light waves at a combination of wavelengths that are special to that particular type of atom, and different from the wavelengths of light waves that are sent out by any other kind of atom.



Electromagnetic spectrum. Credit: STScI/JHU/NASA

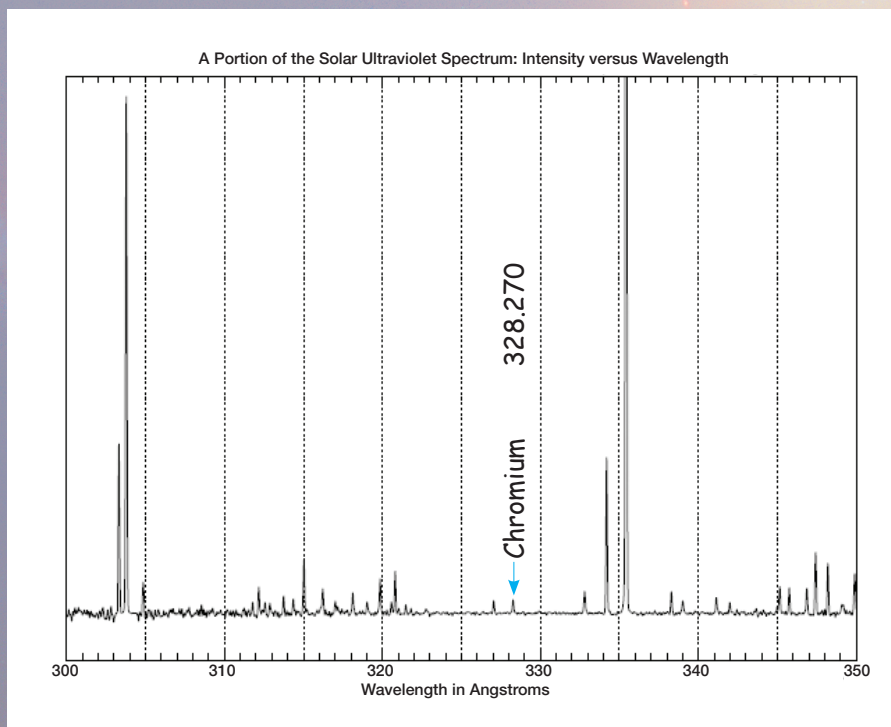


Colors of visible light from longest wavelengths (red) to shortest (violet).

Can you note these elements on the graph?

Element	Wavelength (Å)
Iron	335.418
Silicon	303.317
Helium	303.782
Magnesium	315.029

Example:
Chromium 328.270



This is part of Sun's spectrum obtained by Solar Extreme-ultraviolet Research Telescope and Spectrograph (SERTS) sounding rocket.

Answer key

Atmospheric layers: Mesosphere, Stratosphere, Exosphere, Troposphere, Thermosphere

Word Search:

T K C C S G I R N J P S U W L
 I E A E A S E R Y X C Q H P A
 H O C L L T Z D E I D T B G A
 G I A H S V L Z E E E O B D U
 F X G O N T G N I D N U O S R
 Y R O B S I T I A X S I L N O
 O B O D K I C W C D U S G A R
 D K G C S V Y I M V S R O N A
 A F Z T K P B A A W T C A X E
 O P L A N E T S C N A A C U N
 L S R A T S T U U W I Z I O P
 Y X S F L F L I K P N T G J Y
 A I A X A C U J M N E L A A U
 P H Q U Q H H G E F R I Z X K
 O X K N Z V P N H Y Z E E D O

Words from Rocket: Rock, Core, Tock (as in Tick, Tock), Cot, Rot, Rote

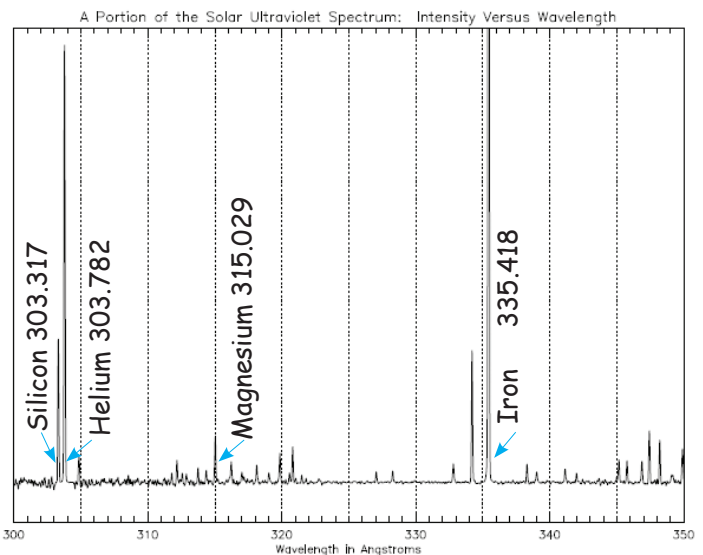
Relationship between atmospheric density and altitude:

When altitude goes up, density goes down, i.e. the higher up in the atmosphere you go, the less dense the air is.

World wide launch sites:



Sun's spectrum:



National Aeronautics and Space Administration
 Goddard Space Flight Center
 Wallops Flight Facility
 34200 Fulton Street
 Wallops Island, VA 23337
www.nasa.gov/centers/wallops

www.nasa.gov

NP-2019-10-405-WFF