

Student-Led Outreach on Light and Atoms

**Elizabeth H. Simmons,
Michigan State University**

Dean of Lyman Briggs College and Professor of Physics



Lyman Briggs is an undergraduate, residential learning community at MSU, devoted to studying the natural sciences and their impact on society. Its building houses laboratories, classrooms, and student residential, dining, and recreational facilities. With 1800 students, LBC offers the “best of both worlds”: the benefits of a liberal arts college and the resources of a great research university.



Flint schools & teachers participating in Spartan Science Day

Brownell Elementary School
Ms. Catanja Harrison



Williams Elementary School
Ms. Karen LaLonde



80 kilometers apart

5th grade students visiting from Flint,
waiting for the program to begin.



MSU's student-run Science Theatre performs demonstrations:



... including a Dance of the
Sound Vibrations...



... Flint students get in on the act!



Making slime with Dr. LaDuca



Microscopes & Cells with Drs Luckie, Smith & Urquhart



Perspective from Flint teachers

- **Many of my students come from homes where no one has ever gotten past high school.**
- **When I talk to my students about college and career plans they say “My mom says poor kids can’t go to college....” This trip helps counter what they’re hearing at home.**
- **Many students didn’t know what a college was before this day and had never set foot in one before... they left the program saying “I want to go there!”**
- **The MSU students were awesome with the kids, even with those who usually present behavior problems. There was a spirit of camaraderie.**
- **One of the best field trips EVER!**

Perspective of MSU Student Organizers

- **[T]he kids we were targeting are among the least privileged kids in the entire state - some coming from families that earn less than \$8000 per year. Many of those kids have no idea what it means to go to college I am hopeful that as they grow up, they'll remember the fun they had at MSU and will see college as a realistic goal, not as an unrealistic dream.**
- **At the end of the day, just before the kids left, we asked how many of the kids would like to go to college someday. And when almost every single one of them raised their hand, that gave me all the satisfaction and reward that I needed for all the work that was put into it.**
- **Getting ten and eleven year old kids excited about science experiments, physics demonstrations and the use of technology could be paramount to their desire for education.**
- **I know I gained a greater sense of appreciation for my education, and those that have guided me along the way, i.e. parents and teachers.**

End of the Program

(Can you spot the physics handout?)



Physics Activities on Light and Atoms

<https://www.msu.edu/~sekhar/ewsb/outreach.html>

MSU Honors College Students:

Garrett Warnell 2005-06

Edita Klimyte 2006-07

Tyler Augst 2007-08

Jamie Overbeek 2008-09

MSU Physics Professors

E.H. Simmons and R.S. Chivukula



Diffraction Grating

A grating is made by pressing into a hard surface a series of parallel lines. A diffraction grating is a piece of glass with many closely spaced parallel lines. When light passes through the grating, it is split into its component colors. The light that passes through the grating is split into its component colors. The light that passes through the grating is split into its component colors.

Atomic Spectra

to better understand the emission spectra that atoms have, try looking through the diffraction grating. Look outside with the spectroscope. What kind of spectrum does nature light give?

The spectrum looks like a rainbow because natural light made up of all colors.

Now look at a fluorescent light with the spectroscope. Is this spectrum different from the one belonging to natural light?

The answer is yes. This is because fluorescent lights produce only certain colors of light. There is no red or orange light in the spectrum. There are only a few discrete lines of light.

Sometimes people try to match the color pattern from unknown materials to the pattern of a known material. This process, known as SPECTROSCOPY, can be used to find out what elements are in a material. For example, you can find out the composition of a star by looking at the spectrum of light that it gives off.

Using a Diffraction Grating

Hold the grating over your eye and look through it at a bright light source. The light that passes through the grating is split into its component colors. The light that passes through the grating is split into its component colors.

How is this useful?

Diffraction gratings can be used to explore the light emitted by different sources such as the sun, distant stars, and fluorescent lights. Other materials emit light in a way that is unique to that material. The emission spectrum of light tells us what elements the light source is made of. An emission spectrum tells us what elements there are between the light source and the observer. For example, you can find out the composition of a star by looking at the spectrum of light that it gives off.

Available Handouts

Atomic Spectra- information about emission spectra and how to use a diffraction grating

Atomic Model- instructions for building an atomic model using plastic containers and candies

Photon Emission- information about photons, photon emission, energy, frequency, and the atomic spectrum

Discharge Spectra- sample discharge spectra for Hydrogen, Helium, Mercury, and Uranium

Fundamental Particles- outline of particles that make up the atom

How We Know- information about technology that allows us to identify atoms, nuclei, and electrons

Subatomic Interactions (2)- a front and back handout about the four main forces: gravity, electromagnetism, strong nuclear, and weak nuclear

History of the Atomic Model (15) - from Democritus to Quantum Mechanics via experiments

The Building Blocks of Matter

Protons $+$

The proton is a particle that appears in the nucleus of atoms and has a charge of $+1$. However, the proton is not composed of three quarks – two up quarks and one down quark.

Electrons $-$

Electrons, the quarks, are not components of atoms. Electrons are found outside the nucleus. Electrons have a charge of -1 .

Quarks

One of the basic particles of matter, a quark always combines with other quarks to form baryons (protons and neutrons). The up quark has a charge of $+\frac{2}{3}$ and the down quark has a charge of $-\frac{1}{3}$.

The Atom

All of the particles to the left come together to form an atom. The atom contains two protons, two neutrons, and two electrons. The number of protons is equal to the number of electrons. This is so that the atom has no overall charge.

Neutrons

The neutron is very similar to the proton in that it is also composed of three quarks. However, the neutron contains two down quarks and only one up quark. This accounts for the difference in charge between the neutron and the proton – the neutron has no charge.

Elements and Isotopes

Elements are made up of atoms. Atoms are made up of protons, neutrons, and electrons. The number of protons in an atom is called the atomic number. The number of neutrons in an atom is called the mass number. The number of electrons in an atom is equal to the number of protons.

How to Build an Atom

The general rules for building an atom are:

- 1. The number of protons must equal the number of electrons.
- 2. The number of protons plus the number of neutrons must equal the mass number.
- 3. The number of protons must be less than or equal to the number of neutrons.

Nuclear Fusion

Nuclear fusion is the process by which two light nuclei combine to form a heavier nucleus. This process releases a large amount of energy. The sun is a natural example of nuclear fusion.

Observing the Invisible

ATOMS

Atoms are made up of protons, neutrons, and electrons. The protons and neutrons are in the nucleus, and the electrons are outside the nucleus.

NUCLEI

The nucleus is the central part of an atom. It is made up of protons and neutrons. The protons have a positive charge, and the neutrons have no charge.

ELECTRONS

Electrons are small particles that orbit the nucleus. They have a negative charge.

Light and Atoms

Energy, frequency, and the atomic spectrum

Light is made up of photons. Photons are particles of light. They have energy and momentum. The energy of a photon is proportional to its frequency.

The atomic spectrum is the spectrum of light emitted by an atom. It is made up of discrete lines of light. Each line represents a specific energy level.

Sub-atomic Interactions

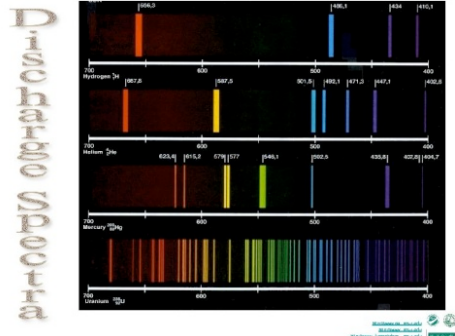
There are two main types of interactions: gravitational and electromagnetic. Gravity is a result of mass attracting another. Electromagnetism is a result of electric charges attracting or repelling each other.

Force, Strength, Carrier, Physical effect

Force	Strength	Carrier	Physical effect
Strong nuclear	1	Gluons	Binds nuclei
Electromagnet	.001	Photons	Light, electricity
Weak nuclear	.00001	Z ⁰ , W ⁺ , W ⁻	Radioactivity
Gravity force	10 ⁻³⁸	Graviton(?)	Gravitation

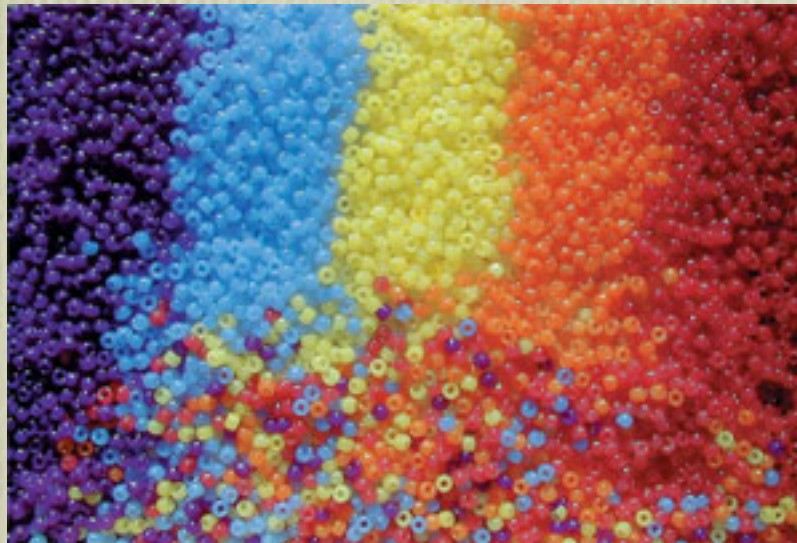
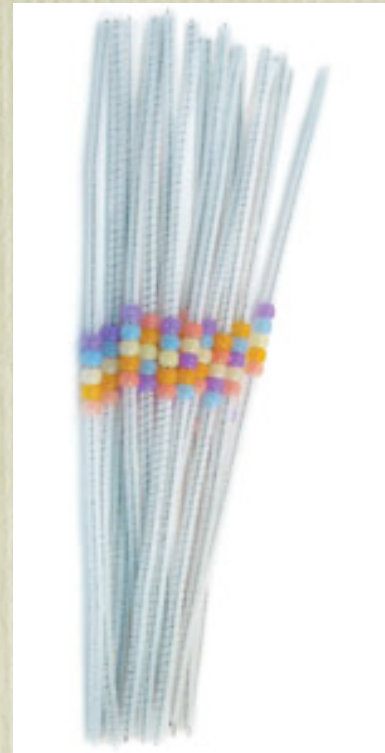
Sub-atomic particles interact by exchanging integer-spin "boson" particles. The varied interactions correspond to exchange of bosons with different characteristics.

THE EXCHANGE OF PARTICLES IS RESPONSIBLE FOR THE FORCES



Ultraviolet (UV) Light

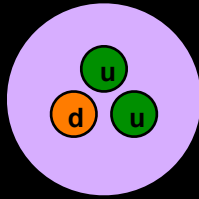
Electromagnetic spectrum
Detecting the invisible
Light and color
UV rays and sunburn
Devising experiments
Take-home detector



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Innovations** INC
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The Building Blocks of Matter

Protons



The **proton** is a particle that appears in the nucleus of atoms and has a **charge of +1**. However, the proton itself is composed of three quarks – two **up quarks** and one **down quark**.

Electrons



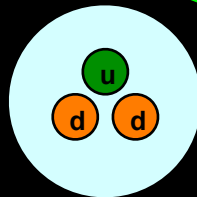
Electron, like quarks, are not combinations of any smaller particles. The electron has considerably less mass than even a quark, and has an **overall charge of -1**.

Quarks

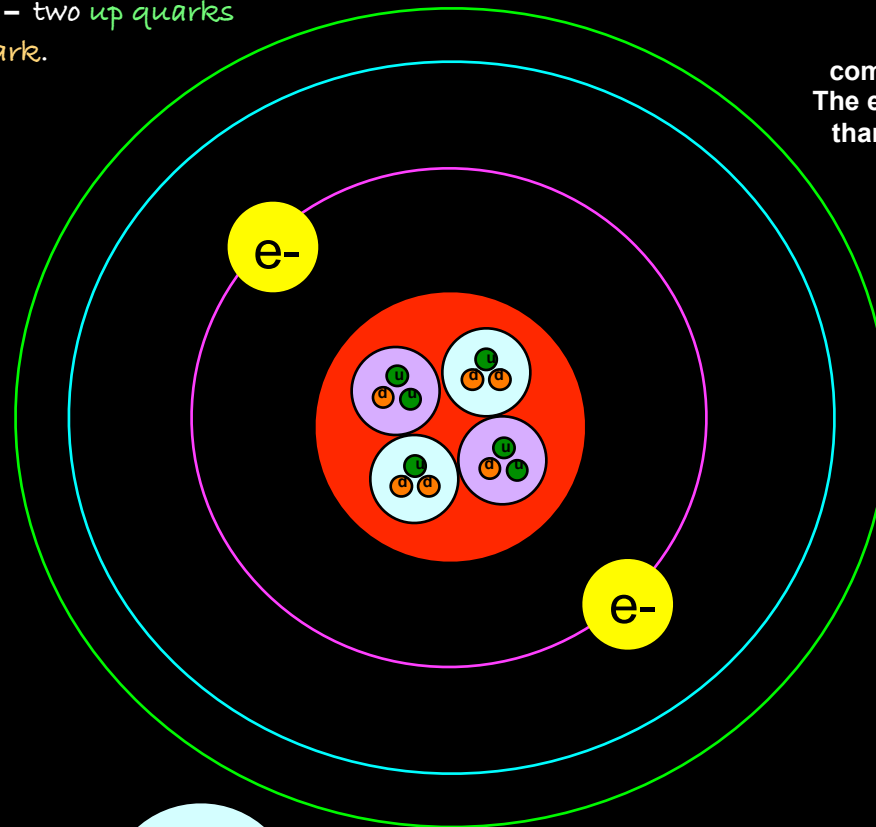


One of the basic particles of matter, a **quark** always combines with other quarks to form larger structures. Protons and neutrons are made out of **up** and **down** quarks. The up quark has a charge of **+2/3** and the down quark has a charge of **-1/3**.

Neutrons



The **neutron** is very similar to the proton in that it is also composed of three quarks. However, the neutron contains two **down quarks** and only one **up quark**. This accounts for the difference in charge between the neutron and the proton – the neutron has **no charge**.



*This Helium atom is not to scale.

The Atom

All of the particles to the left come together to form an **atom**. This one contains two neutrons, two protons, and two electrons.

Notice the number of protons is equal to the number of electrons. This is so their charges will cancel ($-2 + 2 = 0$), and as a result the atom itself will have **no charge**.

Large collections of atoms make up the substances you see every day. For example, the atom shown is **Helium**, the gas inside floating balloons.

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Elements and Isotopes

An **atom** is the smallest particle of an **element** that retains its chemical properties. The nucleus, or center, of an atom is composed of positively charged particles called protons and neutral particles called neutrons (both of which are made up of even smaller particles called quarks). Atoms of the same **element** have the same number of protons. To balance out the positive charge of the protons, negatively charged particles called electrons orbit the nucleus. In neutral atom, the number of electrons is always equal to the number of protons.

Isotopes are versions of an element that have different numbers of neutrons, but the same number of protons. For example, one isotope of hydrogen is deuterium. While the common hydrogen only has an electron and a proton, the isotope deuterium has an electron, a proton, and a neutron.

The following is a table of some atoms and their isotopes:

Isotope Name	Protons	Neutrons
Hydrogen	1	0
Deuterium (Hydrogen-2)	1	1
Tritium (Hydrogen-3)	1	2
Helium-3	2	1
Helium	2	2
Lithium	3	3
Beryllium	4	4
Boron	5	5
Carbon	6	6
Carbon – 14	6	8

How to Build an Atom

The materials below represent the different elementary particles of matter:



Up Quark +2/3 charge



Down Quark -1/3 charge

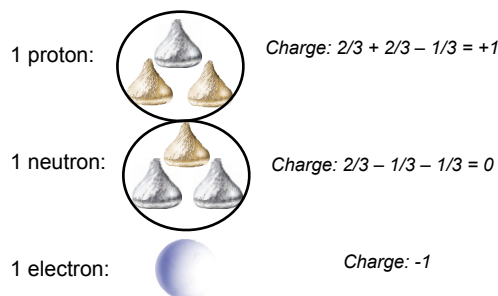


Electron -1 charge

To group quarks into protons and neutrons, place them in a small Tupperware container. To add the protons and neutrons into an atom, place their small Tupperware containers in a larger one. To add electrons, simply screw the lid of a big container on over the string connected to the ping pong balls so the end with the ball is hanging out.

Here's an example to get you started. Notice which quarks go together to form a proton, and which go together to make a neutron

Deuterium



You can see the deuterium atom set up on the table

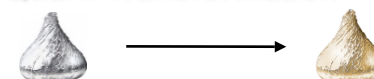
Can you build some of the atoms in the table to the left?

Nuclear Fusion



In the center of stars, it is possible for the nuclei of atoms to combine in a process referred to as **nuclear fusion**. In our Sun the most common fusion process that occurs is the fusing of hydrogen into helium. Since hydrogen has one proton, fusing that proton with another would form a nucleus with two protons. Because this new atom would have a different number of protons, it is now a new element – helium. But helium also contains neutrons. Where do they come from?

Quark Transformation



Sometimes, quarks can change from one type to another. Through this process, a neutron is able to become a proton, or vice versa. This is accomplished through a down quark in the neutron transforming into an up quark. During the transformation, an electron and a nearly undetectable neutral particle called a neutrino are given off. When hydrogen fuses into helium, the helium gains its neutrons through quark transformation. In the Sun, nuclear fusion reactions combine four protons to form one Helium nucleus, giving off two neutrinos and two antimatter electrons. The same process can transform Tritium into Helium-3 (see the table to the left).

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**Let's build some atoms
from chocolate!**

