The Diffraction of Laser Light Through Copper Sulfate Crystals

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Submitted to:
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May 12, 2010

Abstract:

The diffraction of light occurs when light bends around objects that are in its way. The project that was conducted is the process of laser light passing through copper sulfate crystals. In this project laser light was used to see if copper sulfate crystals will cause the laser light to diffract. In order to see if the light diffracts copper sulfate crystals will be created (they will be created by mixing water and copper sulfate into a super-saturated solution, then left for crystallization). Once created the crystals are to be taken into a dark, windowless room. Then Helium: Neon laser light will be shined through the crystal; if any of the laser's light is diffracted it will be able to be seen on the object placed in front of it, in this case poster board. One can tell if light diffracts because it will form an up and down dotted line pattern on the surface in which it is shined on. Joseph von Fraunhofer's law of diffractions will be used to calculate the spacing between the atoms that causes the light to diffract.

Introduction:

The project investigated was what are the effects of laser light on a single copper sulfate crystal. The project is going to be broken into three different parts. Part one is going to be forming a copper sulfate crystal. This is going to be not just any kind of a copper sulfate crystal, a good quality crystal. Part two is going to be finding if a copper sulfate's optic region will diffract laser light.

There are seven different types of crystal shapes: Cubic or Isomeric, Tetragonal, Orthorhombic, Hexagonal, Trigonal, Triclinic and Monoclinic (Anne Marie, ND). A cubic or isomeric crystal is not necessarily cube shaped, it can also be eight faced or dodecahedrons (ten-faced). A tetragonal crystal is similar to a cubic crystal but longer along one axis, forming double pyramids and prisms. An orthorhombic crystal is shaped like two pyramids stuck

together. A hexagonal crystal is a six sided prism. When looked at the crystal on end, the cross section is a hexagon. A trigonal crystal possesses a single three fold axis of rotation. A triclinic crystal is usually not symmetrical from one side to another. Finally a monoclinic crystal is like a slanted tetragonal crystal.

Their are four main categories of crystal based on their chemical and physical properties.

Covalent Crystals- A covalent crystal has true covalent bonds between all atoms in the crystal, almost like one big molecule.

Metalic Crystals- Individual metal atoms of metallic crystals sit on lattice sites, leaving outer electrons free to float around. They are very dense.

Ionic Crystals- In ionic crystals, atoms are held together by electrostatic forces, and have high melting points.

Molecular Crystals- Contain recognizable molecules within their structures. They are held together by non-covalent interactions and tend to be soft with low melting points. (Anne Marie, ND.)

Also good quality crystals should be grown. Good quality crystals mean that they do not have jagged edges, are of decent size (a good size would be about the size of one's thumb nail), and they are transparent. There are several techniques to make crystals of better quality. One way is to not shake, move, or touch the beaker containing the solution while the solution is crystallizing. Another way is to keep the solution pure, which can be done by placing a coffee filter over the top of the beaker which holds the solution, this is to keep all foreign containments out. And lastly make sure everything is dissolved, by filtering the solution and catching anything that did not dissolve. If not everything dissolves it is more likely there will be impurities, which means there will be a lack of consistency in the final crystal.

The crystal that will be grown is a Copper Sulfate Crystal. There are only two substances needed to make this type of a crystal, water and copper sulfate (CuSO4). There are also two different kinds of Copper Sulfate, one kind is anhydrous, this means it contains no water and is usually a pale green or pale white color. The second kind of Copper Sulfate is pentahydrate, meaning it contains water and is a blue color (Figure A). In this experiment the Copper Sulfate was worked with was pentahydrate copper sulfate. Pentahydrate Copper Sulfate is better to work with because it makes better quality crystals because they can form in water.

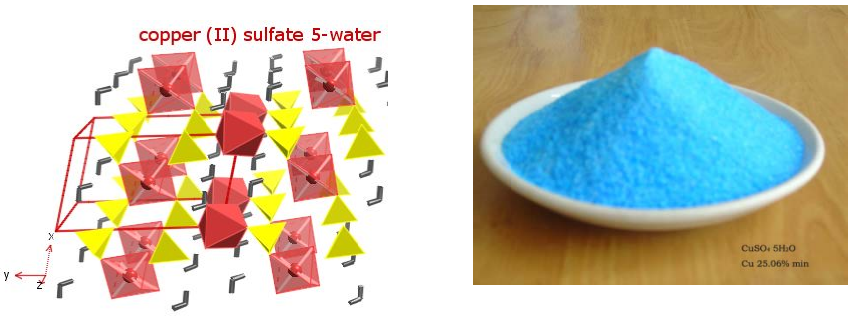


Figure A: Structure of Copper Sulfate in pentahydrate form. (Mark Winter, 1993)

The chemical reaction for Copper Sulfate is:

$$Cu(s) + 2\ H_2SO_4(l) + 3\ H_2O(l) \rightarrow CuSO_4 \cdot 5\ H_2O(s) + SO_2(g)$$

In this reaction the Cu stands for Copper, the H2SO4 stands for Sulfate, and the H2O stands for water. This demonstrates how copper sulfate reacts with water making it pentahydrate copper sulfate.

Copper sulfate is a substance that is produced commercially by reacting various copper compounds with sulfuric acid. CuSO4 is classified as a general use by the Environmental Protection Agency, which means the warning sign “Danger” must appear on any product containing Copper Sulfate (the EPA).It is not very toxic to humans, but can result in death if in

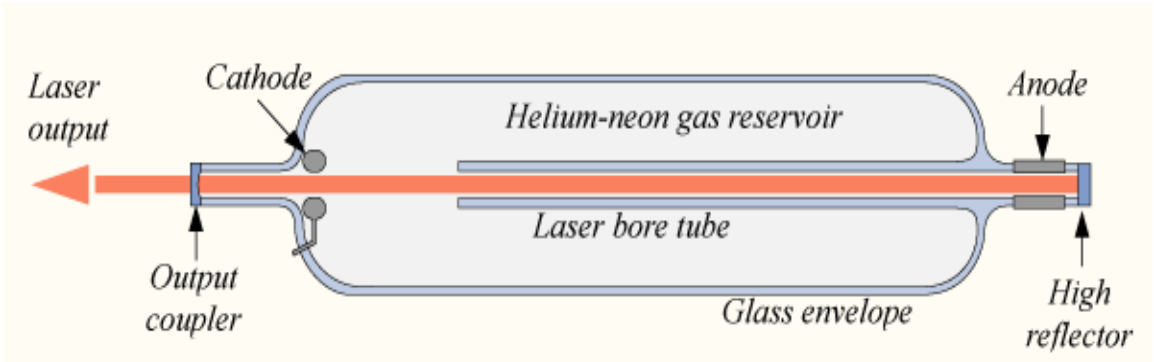
the body. Although Copper Sulfate does not sound like a very helpful compound, it has other uses such as:

- Manufacture of insecticides such as copper arsenite and Paris green Control of algae in swimming pools and lakes.
- Correction of copper deficiency in soils Correction of copper deficiency in animals
- Growth stimulant for fattening pigs and broiler chickens
- Molluscicide for the destruction of slugs and snails, particularly the snail host of the liver fluke(Way. T. N.D.)

The technique used to prepare a Copper Sulfate Crystal is very important because if it is handled poorly, it can turn back into the original Copper Sulfate that was used to create the crystal. This would occur when the already made crystal is put into a jar of water and was left to sit over night. When looked at the next day, the crystal that was put into the jar will not be there anymore because it will dissolve in the water. Also if left in a very bright or hot place, the bright blue crystal may turn in to a pale powdery substance (anhydrous copper sulfate). Copper Sulfate melts at 30 C and all water molecules will dehydrate at 110 C (Winters, 1993).

The second phase of this experiment involves finding how the Copper Sulfate Crystal will reflect or refract laser light. This is going to be done by shining helium: neon laser light through the Copper Sulfate Crystal and finding how the light diffracts. The light will be shined through the crystal onto a flat background. The structure of the crystal will either cause the laser light to diffract in a isotropic manor, which means the scattering of light will have the same intensity in all directions, or in an anisotropic manor, meaning the intensity of the laser light will vary with parts appearing dark from some viewpoints, and illuminated at other angles. To help

identify if the light refracts the room will be dark so the laser light can be see. BY keeping the room dark, the light will be easier to see, making it easier to identify which type of characteristic the Crystal has. Refraction is when a wave encounters the boundary but does not pass into the second medium, instead immediately changing course and returning to the original medium, typically reflecting from the surface at the same angle at which it contacted it. Refraction is the bending of wave when it enters medium where it's speed is different (Mifflin H. N.D.). The laser that will be used is a helium: neon laser light. The helium: neon laser is also referred to as the He: Ne laser because He on the periodic table is helium and Ne is neon. The usual operation wavelength is 632.8 nm.REF Nm is equal to one billionth of a meter in the metric system. The HeNe laser can vary in size anywhere from one centimeter to five centimeters in diameter in up to several meters in length. A normal HeNe laser will consist of the optical cavity at one end of the laser, which is a high reflecting mirror, and at the other end is output coupler mirror, which extracts only a portion of the laser beam (in the case of a HeNe laser only one percent of the laser is absorbed). The laser is reflected off of the mirrors with an electric discharge of about one thousand volts, which go through an anode and a cathode. An anode is a positive terminal on a helium: neon laser and the cathode is the negative terminal. The electric discharge will flow through the positive end and into the negative end of the chamber.



Procedure:

In this experiment copper sulfate crystals are to be grown. The crystals are grown by adding 73g of copper sulfate to 200mL of water in a beaker. After combining the water and copper sulfate, the beaker is to be placed onto a hot plate at over 100°C a magnetic stirrer is then to be added to the beaker, then turn the "stir" on the hotplate on. Allow the copper sulfate to dissolve in the water. After only 2 days crystals should appear on the bottom and along the sides of the beaker. The longer the solution is left undisturbed the more crystals will be formed. The crystals will form be better shaped if the beaker is left undisturbed. Different conditions will be attempted to develop the best, most uniform crystals. After the crystals have formed they are to be taken out and filed down to a reasonable size, Helium: Neon laser light is to then be shined though the copper sulfate crystal in a dark windowless room or a dark box, and if the laser light diffracts it should appear in multiple places. If the light diffracts calculations are to be taken between each spot the light hit. After, another copper sulfate crystal should be taken from the beaker(more than one crystal will be made) and laser light is to be shined through this new crystal in a dark room, or dark box, and if the light diffracts mark the spots the laser light hits and calculate distance between each mark. The tests should be compared.

Summary:

Do copper sulfate crystals cause Helium: Neon laser light to diffract? The diffraction of light occurs when light bends around objects that are in its way. Diffraction can be identified when light is refracted off an object and forms a dotted line pattern. In this experiment Joseph von Fraunhofer's law of diffraction would have been used to calculate the spacing between the atoms that causes the light to diffract.

The laser that was used in this experiment was a helium: neon laser light. The helium: neon laser is also referred to as the He: Ne laser because He on the periodic table is helium and Ne is neon. The usual operation wavelength is 632.8 which is equal to one billionth of a meter in the metric system (when it comes to diffraction wave length is very important because if it is too big the light will not diffract). The HeNe laser can vary in size anywhere from one centimeter to five centimeters in diameter in up to several meters in length. A normal HeNe laser will consist of the optical cavity at one end of the laser, which is a high reflecting mirror, and at the other end is output coupler mirror, which extracts only a portion of the laser beam (in the case of a HeNe laser only one percent of the laser is absorbed). The laser is reflected off of the mirrors with an electric discharge of about one thousand volts, which go through an anode and a cathode. An anode is a positive terminal on helium: neon laser and the cathode is the negative terminal. The electric discharge will flow through the positive end and into the negative end of the chamber.

The substance that was used to create copper sulfate crystals was copper sulfate. There are also two different kinds of Copper Sulfate, one kind is anhydrous, this means it contains no water and it is usually a pale green or pale white color. The second kind of Copper Sulfate is pentahydrate, meaning it contains water and is a blue color. In this experiment the pentahydrate copper sulfate was used to make the crystals. Although in this experiment copper sulfate was used to make crystals it has many other uses such as: Growth stimulant for fattening pigs and broiler chickens, used to kill slugs, and can be used to control the growth algae in pools, lakes, and ponds.

In order for this project to be carried out a succession of experiments had to be done. The first experiment that was conducted was the growing of Copper Sulfate Crystals. The crystals were grown by adding 73g of copper sulfate to 200mL of water in a beaker. After combining the

water and copper sulfate, the beaker was placed onto a hot plate at a temperature of 100°C or more and a magnetic stirrer was then added to the beaker, then the “stir” on the hotplate was turned on. After all the copper sulfate was dissolved the solution was left to sit for a few days. After only 2 days crystals appeared on the bottom and along the sides the beaker.

The second part of the experiment was testing for diffraction. The tests for diffraction were conducted with two ring stands, two ring stand clamps, several copper sulfate crystals, a He: Ne laser, and a blank wall or board to shine the laser onto. First one of the crystals was placed in the clamp on one of the ring stands and on the other ring stand, which stood 30 cm apart, was the He: Ne laser. Ten centimeters past the ring stand that held the laser pointer was the poster bored or blank wall. The laser pointer was then shined through the crystal onto the bored or wall where any sign of diffraction would be visible.

Data:

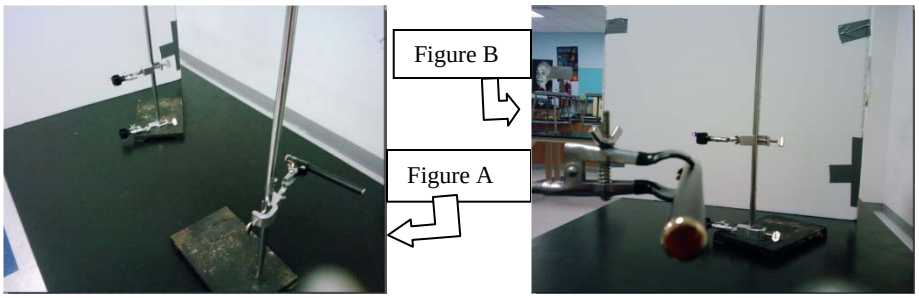
Crystal Used:	Crystal A:	Crystal B:
Conclusion:	Did not cause the laser light to diffract.	Did not cause the laser light to diffract.

The conclusion to this experiment was that copper sulfate crystals do not diffract He: Ne laser light, but instead reflects it. This is inferred because the light from the laser does not show any patterns of diffraction on the board after being shined on the crystal. But the light from the laser did reflect back onto a surface behind the laser. Although some parts of reflection can be measured, for instance the angle in which the light hits and object will have the same angle when it reflects off the object, but in the example of diffraction that was found could not be calculated because it showed no specific angles.

Finally it is assumed that the size of the laser (650 nm) was too big to fit between the atoms of a copper sulfate crystal, preventing any sign of diffraction.

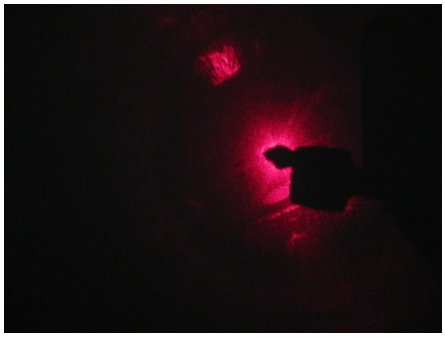
Conclusion:

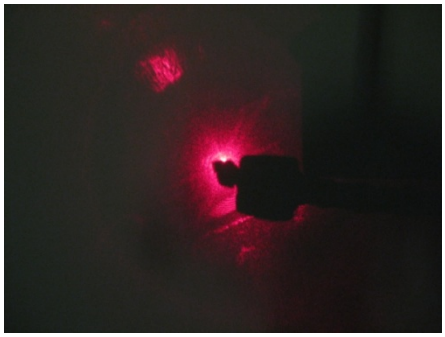
The question being addressed in this experiment was to determine the effect of laser light on copper sulfate crystals. In order to conduct this experiment copper sulfate crystals had to be grown. Once they were grown they were put in the clamp of a ring stand. On a second ring stand was a He: Ne laser which was pointed towards the crystal on the other stand. Once the laser light was shone on the crystal, light either diffracted or reflected onto the poster board behind both ring stands, as seen in figures A and B.



Based on the pattern of light formed on the poster board one would conclude that light is not diffracted when shined off of the surface of a copper sulfate crystal but rather reflected. This information was inferred after a dotted line pattern, which indicates the presence of diffraction, did not appear on the poster board. Instead the light appeared to reflected back toward the laser. In other words the laser light that was suppose to form a diffraction pattern instead reflected back onto an object behind the laser. It is thought that because the light did not diffract that the molecules that would cause the light to diffract were smaller than the light, making it reflect not diffract.

Although the light did not form a pattern in the form of diffraction there were several different patterns on the board. These patterns made the shape of a finger print. In order to conclude that these were real patters the crystal was turned, moved closer and further away, and taken away. It is inferred that the crystal did not cause the pattern because the pattern still remained on the board even when the crystal was not there.





If this test could be done over again there would be some changes. The first change that could be done is more research would have be done before growing the crystals. If more research had been done then there would have been a better probability that the crystals grown would have been of better quality, meaning they would have been a decent size, smooth not jagged, and clear and not smoggy. The next thing that would have changed is the laser used. The laser that was used had a dirty lens that had dust and a finger print on it altering the results. If a clean laser was used the results could have been more reliable. Also if a more precise laser had been used there would have been a better chance of diffraction.