Rochester Astronomy Club

Presentation Notes 2026-03-24

19:04 – start with presentation.

Presentation: Cataracts and the Amateur Astronomer: A paper by Kathy and Jerry Oltion

Reviewed by Jay W. McLaren, Ph.D., Professor of Ophthalmology

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19:06 - Started with a paper Josef gave to Jay last summer. Josef said this is probably a good one for the group. Many of us are making it to that age.

Also talk about physical optics and diffraction.

Jerry Oltion - A columnist for _Sky & Telescope_ from 2016 to 2025. He is also a writer: He has published 15 science fiction novels. He has had multiple other jobs including being a carpenter, an oil field worker, a DJ, and even a garbage truck driver. Most of all, he is an amateur astronomer.

The paper is about the experience Jerry's wife had after developing cataracts, getting surgery, and ending up with an interesting complication.

The paper was published in Sky & Telescope in 2014, but you can go to his website and download a copy of it.

Review of the anatomy of an eye, pathology of cataracts, how cataracts are treated, and considerations over what can go wrong. Diffraction plays a big role in this.

Also go over a solution to the problem, based on Kathy's experience.

Image of an example of a slit examination of an eye. A thin beam of light, about 0.10-millimeter width. It lights up the cornea, about 0.50-millimeter thick.

Anterior chamber behind the cornea, filled with a clear fluid called aqueous humor.

The crystalline lens behind that is what becomes deteriorated when you develop cataracts.

The area behind the lens is filled with vitreous humor. Vitreous humor is thick; the aqueous humor is thin like water.

There is a lens capsule, a thin layer that goes all the way around the crystalline lens.

The crystalline lens has about a third of the optical power of the entire system. It can change the focal length of the optical system. Most of the optical power is in the cornea due to refraction change from air to the corneal tissue.

The lens starts out as a nucleus before you are born. Layers are added to it as you grow up. The proteins that make up the layers add kind of like layers of an onion.

The proteins are arranged in a very uniform spacing creating constructive interference, like crystalline quartz. Clear instead of cloudy.

Suspensory ligaments attached to the side of the lens. These are attached to the ciliary muscle. The lens can be flattened, accommodation, allow change of focal length. Tension flat, relaxed thick. Zonule, what ciliary muscle attached to.

The lens gets stiffer as we get older. We lose the ability to accommodate, then we must wear bifocals to see things that are closer. A comfortable reading distance is about 25 centimeters.

Cataract: Some material gets in the lens that does not belong there, or the proteins in the lens change their characteristics and start to become opaque or translucent, light scatters.

Instead of a clear image of a star, you see a star with a halo around it. Streetlights at night have halos or distortion. This is called "forward scatter" (glare).

You could also have local defects in the lens causing focus in different areas as well as scattering, resulting in seeing multiple images. Kathy saw three images of Saturn when observing, that suggests that she had these local defects in her lens.

Treatment: The treatment for cataracts is generally the removal of the lens. Optical power needs to be replaced. They used to replace it with glasses that had very thick lenses. Now the removed lens is replaced with an IOL, an **i**nter**o**cular **l**ens.

The technology for IOLs was first developed at Saint Thomas Hospital in London. Sir Thomas Ridley (Sir Nicholas Ridley?), a doctor, did the first lens replacement, November 29th, 1949. He was an ophthalmologist for fighter pilots during WWII. The bulletproof canopies of fighter planes were made of Plexiglas. Sometimes the bullets that hit the canopy would send out shards of the Plexiglas. The pilot he was treating had some of these shards in his eye. He decided to leave the shards of Plexiglas in the pilot's eye, instead of attempting to remove them. After following the patient over the years, the eye did not react to leaving the shards in his eye.

PMMA (the material that makes up Plexiglas) is inert when put in the eye. This gave him the idea of using it to replace a natural lens with that material.

Technology has changed since 1949, now they make a small 3-mm incision in the cornea, open the capsule that goes around the lens, and remove the lens. A phacoemulsifier is used to remove the lens. This device has a little plunger on the end that can move back and forth in a stroke of 50 to 150 microns, at a rate of 35 to 45 kilohertz (ultrasonic). This causes a cavitation that breaks up the cataract. A port flushes saline in and aspirates saline out with the tiny pieces of broken up lens. It takes about 10 minutes to remove the cataract.

The replacement lenses now are flexible. They can be rolled like a taco, put in an inserter that fits through the 3mm incision, then it is unfolded inside the capsule. Haptics, little wires or fish lines that come out of the sides of the IOL, are used to stabilize the lens in the capsule, keeping it from shifting around. The haptics will play a role in the complication to be described.

Kathy had this cataract removal and lens replacement surgery done. When she looked at Saturn, she no longer saw three images. However, she did see lines or spikes. What she saw reminds one of the diffraction spikes seen when looking at a bright star through a Newtonian telescope.

Example NGC 2419, C25 from Wikimedia Commons. Bright spikes coming out.

So, now we get off on a tangent: **diffraction**.

Examples of changing the path of light include:

- Reflection
- Refraction
- Scatter (what we just talked about)
- Diffraction

Diffraction is caused when light is attenuated by a stop of some kind.

A review of light, an electromagnetic wave. Visible light has a wavelength of 400 nanometers (violet) to 750 nanometers (red). The frequency of light is about 400 to 700 terahertz (1 terahertz = 1000 gigahertz). Light also has particle characteristics or photons. If you get down to very low intensity, light comes in pulses or packets. A packet of light comes in a photon.

Interference:

- constructive interference - bright.
- destructive interference - dim.

Wave propagation through a small opening. A wave front from a point source is formed, resulting in many point sources if there are many openings. The spacing of the openings results in waves out of phase from each other. A similar thing happens with water waves.

Two-slit diffraction: alternating light/dark bands.

Obstruction diffraction: Similar to the two-slit, but weaker.

Diffraction is always perpendicular to the obstruction.

Bahtinov Mask. A tool used to purposely create diffraction. One puts this over the front of a telescope. It creates three diffraction lines that do not intersect when the image is out of focus. The diffraction lines come together when in focus, intersecting at a point. This makes it easier to focus rather than judging the focus based on the blur. This tool can be used for getting a good focus from your telescope, especially when using a camera to take photographs.

Examples see a rainbow blue closer to the center than red.

Diffraction by Round Aperture. This occurs in refracting telescopes. It was first described by George Biddell Airy (1801-1892), a British astronomer. FWHM - Full-Width Half-Maximum.

$\Theta_{FWHM} \approx 1.029\ \lambda/d$

λ = the wavelength of the light.

d = the diameter of the aperture.

If you have a small aperture, you will have a larger Airy disk. Diffraction occurs at the edges of a lens. If you have a 60mm telescope and you use 400x magnification, you will get a rather large Airy disk. This is what typically occurs with department store telescopes.

LASER diffraction demos (green LASER pointer):

1. Two razor blades about 0.2mm apart: a slit.
2. A single piece of fish line (braided).
3. Three pieces of fish line, close together.
4. A diffraction grading, from Randy, 500 lines per millimeter.

Keep in mind that the light from a LASER is one wavelength.

Q - Luka had a question: Would blue LASERs have the dots closer together? Jay said that, yes, a blue LASER would have dots closer together than a green LASER, a red LASER would have dots further apart.

An example using a flashlight was shown as well. One could see a rainbow effect.

Jay described how a grating with a tiny slit is used to get spectral lines from star light. The spectral lines are used to determine what materials/elements are in a star.

Jay also demonstrated an attachment that came with his laser pointer. Luka has a similar attachment that has adjustable spacing. Jay explained that the spin adjusts things by changing the orientation of one grating versus the other.

OK, resume. **What does this have to do with Kathy's cataract problems?**

Retroillumination: Focus on the front of eye illuminated from the back. This allows one to see the haptics of the IOL. A clarification that the aqueous humor is NOT completely removed. Jay pointed out that what is lost during the operation refills in about an hour after. Jay also pointed out that the incision is self-healing as well, so no sutures are needed.

During the retroillumination of Kathy's eye, a wrinkle was seen in the back. Tension from the haptics was pushing out on the capsule, causing a fold on the back of the lens capsule. This caused the diffraction. It is a rather common occurrence, called capsular folds, but most patients do not notice it, or are not bothered by this. Kathy is an astronomer, she noticed.

The solution is to remove the posterior capsular fold using a LASER. This is called posterior capsulotomy. There is no opening needed. A neodymium-YAG LASER is used. The light from the LASER goes through the lens and is focused to a point.

The wavelength of a neodymium-YAG LASER is 1064 nanometers, in the infrared range, double of 532 nanometers, which is green. In the green LASER pointers commonly used as pointers, a crystal doubles the frequency. Doubling the frequency gives you half the wavelength. Neodymium is the element that does the actual LASING. YAG is yttrium-aluminum-garnet, a crystal substrate.

The LASER for the operation does a 3 to 4 nanosecond pulse. The laser delivers 0.5 to 1.5 millijoules (1 watt-second). During the pulse an energy of about 300 kilowatts is delivered to the focus point, which is enough to vaporize tissue. Vaporizing the tissue with the LASER is used to cut and remove the posterior capsule of the lens.

Secondary cataract: A secondary cataract is a condition where that posterior capsule becomes slightly opaque. This usually occurs with a cataract or after a cataract.

Kathy's diffraction issue was fixed after the posterior capsulotomy. She clearly saw Saturn, no more multiple images, no diffraction spikes.

Luka had a question: Can cataract surgery fix astigmatism? Jay said yes, but it is a little more complicated, because they need to get the correct lens orientation.

Q: How long do these lenses last? Jay said that they typically last forever, however, sometimes the body interacts with the lens, and they must be exchanged.

Jay said that if you encounter this (a cataract), it is important to discuss the optical needs of astronomers with your ophthalmologist.

Jay wrote to Jerry about sharing information in the article in a presentation. Jerry wrote back and sent some pictures to share of him and Kathy.

Q and A on "Airy Disk" and aberrations with Luka.

Q and A with Julie and Brandon around removing the posterior capsule. It involves leaving an opening of about 5mm. Ideally as big as a fully dilated pupil, but they want to keep it small, considerations on avoiding vitreous humor and other potential complications. After removing, the capsule posterior can snap back, usually out of the field of view, and it shrinks with time.

There was a question on whether one would want the lens for near or far vision if they are an astronomer. Jay was not certain if it was clear that it differs for an astronomer versus a regular patient. Randy mentioned that the NCRAL had a recent newsletter, the latest one, where Carl chose to preserve his near vision.

Cataracts are yellow. Jay pointed out that this absorbs blue light. People say that their vision after the surgery is more vivid. Luka said that the January Sky & Telescope issue had an article about a guy that convinced his doctor to implant uncoated lenses. He promised to wear sunglasses when outside in the sunlight. He was able to see down into ultraviolet. His article was about his experience with observations of Venus and Jupiter using visible light filters.

Randy and Jay talked about progressive IOL options. Some like that, others do not.

Jay said that another suggestion, not in production yet, is a flexible lens to get accommodation back. There is nothing practical yet.

Randy asked if you could do one eye for near and the other for far vision, like some do with contacts. Yes, that is something they do.

Mike Curry asked Jay about replacing lenses to correct for bad vision. Jay indicated that there are risks with any surgery and most doctors are averse to replacing a clear lens just to correct vision if there are no cataracts.

20:09 – end of presentation.