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Why Do Stars Twinkle?

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If you do an internet search on this question you quickly find that the standard answer is "turbulence in the atmosphere." This appears at first glance to be plausible, so most people accept it and move on. However, upon closer examination, the explanation fails. Turbulence in the atmosphere would affect all light sources, not just dim sources. But planets do not twinkle. The standard answer explains this by asserting that because planets are brighter, the photons from them somehow plow through atmospheric turbulence with little or no effect. But this is illogical. Turbulence affects all light equally, and increasing the brightness of a source should have no effect on it. Brighter light is not bigger or faster photons, it is just more photons, and if one photon is affected by turbulence, then 10 photons will be too, or a million billion. Light much brighter than planet light is affected by turbulence all the time, as the standard answer admits. Most of these standards answers give the reader analogies for the effect of atmospheric turbulence, such as how things look wavy over a hot grill or above a metal roof or above pavement in summer. Well, all things look wavy over a hot grill, not just dim things. No matter what the light is reflecting from, the turbulence affects it equally.

The standard folks will reply that atmospheric turbulence is much less than turbulence over a grill. But this is not to the point. Turbulence of whatever magnitude affects light waves or photons, and it will not affect more photons less than it affects fewer photons.

On the internet site "Ask an Astronomer [Cornell U.]," Dave Kornreich claims that light from planets will "average out" because that light will hit multiple receptors in the eye. Light from stars will hit only one receptor, he claims.

Now, a star on the sky is in a true sense a single point of light. All the light comes through the atmosphere in exactly the same direction, through exactly the same atmospheric turbulence, and thus is bent in exactly the same way. So when it gets to your eye, the amount of light you see coherently varies. It also strikes (primarily) only a single receptor in your eye.

On the other hand, light from a planet is different. Each of a few receptors in your eye sees a large number of light rays coming from the planet, each of which has been bent differently be the atmosphere (since the planet has size on the sky, they are arriving in slightly different directions). Some of these rays will become brighter, some dimmer. But because they all illuminate the same receptor in your eye, that receptor only sees the total amount of light hitting it. There will be about the same number of enhanced rays as dimmed rays, so you experience a steady light, not a twinkle.

But this is a complete misdirection in argument, since even if it were true (it's not) it would explain precisely nothing. In general, hitting multiple receptors will make the object look larger, not brighter. Brightness is determined by photons per second, and a single point source striking only one receptor can look bright if a large number of photons are arriving per second. In fact, to make the star look wavy it must strike multiple adjacent receptors. This smears the image across all the given receptors and makes the star look larger than it is. If different receptors are hit at different times then the image may appear wavy: if it is small enough it will dance about, if it is large only the edges will flutter. Other websites seem to understand this. The NASA answer to this question shows a time lapse image of a star moving about in a random manner [http://antwrp.gsfc.nasa.gov/apod/ap000725.html]. It could not do this if it was striking only one receptor.

Beyond that, Kornreich's answer, due to its form, can only address brightness and size, it cannot address flicker. The averaging he is trying to manufacture is an averaging of rays arriving simultaneously. This might conceivably address size or brightness, but would not affect flicker, since any flicker would be caused by gaps between one arriving wave and the next. All this talk of receptors has nothing to do with explaining these gaps.

And that brings me to my final complaint. All these turbulence explanations treat "flicker" as synonymous with "waviness". But waviness is one thing and flicker is another. What we see over a hot grill and what we see with stars is two different things. We may indeed see some waviness from both stars and planets, and this may indeed be caused by atmospheric turbulence. But the question was what causes twinkling or flickering, and flickering is caused by time gaps in a continuous image.

The proper analogy for twinkling is not the hot grill, it is the old movie. Old movies flickered because there were not enough frames per second: the eye could see the gaps in between frames. This is what we are seeing with twinkling stars. A twinkle is a flicker, not a wobble. And this is why NASA's pictures don't address the question. A series of images like they have posted will not appear to twinkle if it is speeded up, it will wobble. If you speed it up enough, it won't wobble or twinkle, it will just be a smeared image. The star will look larger and that is all.

The standard answer, in whatever form, is wrong. We are told that stars as seen from space do not flicker, and we are shown pictures from orbiting telescopes as proof. But this is proof of nothing, since there is no possible way that a picture can flicker. Only a series of pictures can flicker. A picture can only be more or less sharp. We get sharper pictures from space and that is because all the turbulence and waviness is gone. But my guess is that the flicker from stars remains. The waviness no doubt disappears, but the flicker must remain. The only negative proof I would accept is a continuous image from a movie camera that was built much like the human eye—meaning that it should have the same speed and resolution as the human eye. To my knowledge, this proof does not exist. Our astronauts have been too busy with more important tasks to notice whether or not the stars twinkle. And the high quality moving images we have gotten from space have not included broad sky images, like we would see with the naked eye. They have not included this for two reasons: 1) no one thought it was worth doing, 2) it can't be done. Remember that we are not able to film starlight here on earth, as the human eye sees it. Hollywood often wants to include twinkling stars in motion pictures, but it still has to manufacture these scenes. It used to use pretty naive methods to put stars in the sky, but it now just adds them with CGI. It has to add them because it cannot simply put them on film in a normal way. If Hollywood cannot do it, you can be sure NASA can't, since Hollywood has much bigger budgets.

My belief is that stars appear to twinkle because the human eye sees gaps in the arriving image, and that the gaps are really there. We are seeing a slightly broken image, one that truly flickers over very short intervals. The reason it flickers, even in outer space, has nothing to do with interstellar gas or any other obstruction or turbulence. It has nothing to do with refraction, diffraction, scattering, or any other effect. It has to do only with distance.

A star emits light as a sphere. Let us freeze a frame of emission and study it. At any dt, the maximum amount of light that a star could emit from its surface is a solid sphere of photons. Stars are very large and photons are very small, but there still must be a finite number of photons on the emission sphere. Even if we pack them edge of photon to edge, we still have a limit. We will find a certain finite number of photons emitted at each dt. Now, as this sphere travels out from the surface of the star, it gets larger. With each passing dt the emission sphere increases in radius. As it does so, we must begin to see space in between photons. Obviously, this space will increase as the sphere continues to increase in distance from the star.

Some years later, this light from this given dt on this given star may have reached the earth. At that time, the given sphere of photons must be very large indeed. It may be a sphere as large as a small galaxy, and the space between the photons must be very large also. Indeed, we must expect that the space between photons would by now have become noticeable on a macro level. If this is true, then there is an interesting question, one I had been asking myself for many months. Why does this gap not create a noticeable effect here on earth? If there is a gap between photons arriving from distant stars or other objects, then why can we see these objects from all possible points? You don't just see stars from some points and not others. If you are standing at point A and you see the star, then you also see the star at point B two inches to the side, and point C, two inches higher. Wherever you are, you see the star. How can this be?

Well, I believe the answer is that we see the star from all points simply because we are not seeing just one arriving sheet of light. We are not seeing just one dt worth of photons. We are seeing a continuous or nearly continuous stream composed of sphere after sphere of emitted photons. Each arriving sphere may have huge gaps in between photons, but the image of the object is made up of hundreds or thousands of spheres arriving per second. And there is nothing to say that one sphere will have the same gaps as any other. In fact, we should expect them to be pretty much random. Each emission back at the star was not a fixed or laser emission. It was just a random emission that might settle into the spherical sheet in any number of ways. Because of the huge number of photons being emitted, every place on earth will be getting some photons. No place will be in a permanent or semi-permanent gap.

This may explain why there are no gaps, even at very great distances from stars. But I also realized that it might explain twinkle. There may be no gaps in space, where no photons are arriving. But there must be gaps in time where no photons are arriving. To say it another way, no point on earth is likely to experience a loss of image for any appreciable time, say one second, or even half a second. But all points on earth should expect a loss of image for tiny fractions of seconds, since all points must experience gaps at some (or many) dts. In some cases, purely randomly, these time gaps might stack on one another, leaving a time gap that was noticeable to the human eye. This would cause flicker. Arriving photons from different dts might also stack randomly, momentarily boosting the brightness of the image. This would also cause twinkle. Stars that emitted less visible light would be expected to flicker more, as would stars that were further away. In the first instance the cause would be fewer photons on the original sphere. In the second the cause would be a larger sphere at the distance of the earth, which would cause larger gaps.

This theory would not affect planets, since although planets reflect much much less light than stars emit, they are much closer. The main cause of gaps is distance, and planets are very close. The emission sphere of a planet would not have increased in size enough to begin to create gaps between photons, and therefore we would not expect flicker. No gaps, no flicker.

As a closer, I would like to make one more comment about the standard answer and all the websites that sell it. The internet is full to bristling with official experts. Every university has a public liaison, an "ask an astronomer" or "ask a physicist." And there are thousands of other private sites, many with smug and aggressive titles like "bad astronomy" or "crank physics" or "pseudoscience." Here the expert corrects the misconceptions of those who didn't go to the proper universities and memorize the proper formulae. Then there is Wikipedia, which has set itself up as an unofficial mouthpiece and amateur police force for the scientific status quo. I have found that these official sites and expert sites and encyclopedia sites are the repository of a huge amount of bad thinking and writing. No matter what topic you are researching, you are sure to find some half-baked, though possibly longstanding, theory posing as fact, protected by walls and walls of hyperbole, self-glorification, and intimidation. Accepting this theory without question is a sign of intelligence and questioning it in any way is seen as mysticism, philosophy, metaphysics, pseudoscience, or impertinence. Like most modern science, these half-baked theories exist as bald two-paragraph pronouncements, and anyone who needs more is sent to other sources. These other sources either don't exist or they exist only as a series of esoteric equations. Anyone who can penetrate these equations quickly discovers that they were posted not as confirmation, but as further intimidation. 99% of readers won't be able to penetrate the equations and will give up, which is what is required of them. Of the 1% who do understand the equations, most will already be in academia and will either already accept the standard model or will understand why it is best to keep quiet if you don't. The 1% of 1% who understand the equations and see that they are meaningless and think the standard model is just a bunch of gobblydegook, well, they can be ignored. They will either become the next Einstein by somehow going over everyone's heads (in which case we will just tweak the standard model and go on as before) or they will kill themselves in frustration and we won't have to deal with them anymore.

In this and many other papers I have quoted directly from these official websites, to show what passes for science and scientific thinking these days. I do this to display the irony of smug websites claiming to battle pseudoscience but doing so with pseudoscience of their own. Really there is only official pseudoscience and fringe pseudoscience, since almost nobody is doing any real science or any real thinking. What we have is a gigantic wall of dogma, policed by a truly stupendous number of self-appointed cops. Behind this wall are a couple of dozen theoretical physicists doing all the "thinking." But this thinking has devolved into the sort of ridiculous ad hoc pie-in-the-sky thinking given us by string theory, and before that by quantum mechanics. Nothing has to make sense anymore, and usually it doesn't. But no one is embarrassed by this. They blow ahead at ever increasing rates, taking long breaks to pat each other on the backs and write press releases. Anyone who is old-fashioned enough to expect science to make some sense, contain some logic, be consistent, or be verifiable in any way is immediately shouted down from all quarters as being a philosopher—a naive antediluvian creature whose career and funding obviously doesn't depend on accepting everything he is told.

But even more than that, I have quoted from these sites and attacked all quarters to show how utterly debased the field has become, from top to bottom. Not only do we have tenured professors, journal editors, and referees who can't do high school algebra or basic kinematics, we have an entire subclass of PhD's who have nothing better to do than patrol the internet and the world, attacking anyone who questions the authority of the standard model. For instance, someone like Marilyn vos Savant publishes a book that expresses some doubt about a mathematical finding, and she is immediately attacked personally by thousands of tenured people. These people do not attempt to address the issue she has laid upon the table. They erupt in outrage and offense that someone not in their club would express a mathematical opinion. I find this very strange, not just because it is undemocratic but because it is unscientific. If she is wrong, it should be expressible in a few logical sentences. Outrage is unnecessary.

Science should welcome criticism. It gets way too little criticism from within, and it would appear that the only place it can expect any criticism is from beyond its borders. Science cannot survive without criticism, for the very reason that the strength of a theory depends on its ability to withstand criticism. A theory that suffers no criticism cannot be judged. There is more to verifying a theory than just finding a few bits of experimental confirmation. A theory must be logically airtight. To discover how airtight it is, it must be open to criticism on logical grounds. Meaning that it must show itself to be consistent, falsifiable, non-circular, non-contradictory, non-paradoxical, and so on. Any theory can generate some positive experimental data, as we are seeing now. For instance, in cosmology, an almost infinite number of theories could contain all the experimental data we are now finding, since that data is so limited. It is amazing to see how no theorist ever finds any experimental data to be negative data. The theorist just tweaks the theory to contain the data and moves on. The theory can usually be tweaked in a very small way, one that is almost invisible. But a theory that is so easily tweaked didn't have much content to begin with. If it was not falsified by negative data or predictions, then it was not falsifiable.

As an example, this week's news is that astronomers have just discovered, using a new method, that we have been off by at least 15% in measuring the distances to stars and galaxies. This means that the universe may be 15% older than we thought. But of course it means a whole lot more than that. What it means, basically, is that we don't really have any idea what we are doing, in most cases. Think about it for a moment--15% is a huge amount of error in a basic task, and that error has probably been downplayed for the media. If we have had that kind of unseen margin of error in the most basic task of astronomy, what does that say about the margin of error in the rest of the field? You shouldn't trust someone who can't boil water or break an egg to create a culinary masterpiece. And yet we seem to find no problem in watching astronomers who can't measure the distance to a star go ahead to estimate the age of the universe. These astronomers have the unbelievable effrontery to make both corrections in the same paper, and the same press release. But good god, doctors, what makes you think you are capable of estimating the age of the universe when you can't measure the distance to a star? Maybe you should start over from the beginning.

To estimate the age of the universe requires the juggling of a large amount of known and unknown quantities. If all the "known" quantities are off by at least 15%, then you must multiply each known quantity by 15%. Let us say there are 20 known quantities that are of primary importance in estimating the age of the universe. That would give us a margin of error of 300%. Then, you should expect that you will be more wrong about the unknown quantities than you were about the known quantities. Let us say there are another 20 unknown quantities that are of primary importance in estimating the age of the universe. If we are exceedingly confident, we can imagine we are on average only 30% wrong about each one. Which would give us another 600% error. To find the total minimum error, we must continue to multiply, which means we should expect to be at least 180000% wrong, on a good day.

Which is to say that the dishonesty of the whole enterprise is the worst part of it. It is OK to say we don't know. It is OK to say that with certain questions it is just asinine to even make estimates, unless you have a really beautiful way to estimate without 40 unknowns and semi-knowns. But modern scientists are constitutionally unable to face the unknowns. They cannot be satisfied to work at the level they have actually achieved. They have to race ahead and make ridiculous estimates, and then get offended when people question or disbelieve those estimates. They create a really fantastic amount of unsupported dogma, and then disallow anyone from taking a close look at it. That is not science. It is religion.

This attitude trickles down to much smaller questions, like this one of twinkling. Dave Kornreich admits on the Cornell website that he had never thought about the twinkling question until some child asked him. He couldn't just say, "We don't know, darling" or even worse, "I don't know, darling." He had to dig up the standard answer and no doubt force it down the poor child's throat. She, or someone else, demanded clarification on his "averaging" assertion, an assertion he was foolish enough to have made up on his own. He should have stuck to copying straight from the text. But once he said averaging, he had to defend it, although he obviously had just pulled it from the air. That's when he made up the whole story about receptors. God knows where he got that from. But by then he had used the phrase "coherently varies"* and the child had nodded off and he was saved from further inglories.

I don't claim that my theory of twinkling is true. And I certainly wouldn't be offended if someone criticized it. I simply offer it as an interesting alternative to a standing theory that is not at all satisfactory or consistent. I think once most people think about it, they will see that twinkling is not wavering or wobbling or wiggling, it is flickering. And flickering cannot be explained via turbulence. Beyond that, I have no career or funding that I must protect; I only hope to be of some use to the world.

*How can something "coherently vary"? If light is coherent, it is coherent because it does not vary.