Scintillate, Scintillate Little Star...

Twinkle, twinkle little star
Why d'you twinkle way up thar?
Are you blinking? Or am I?
Or is it something in the sky?

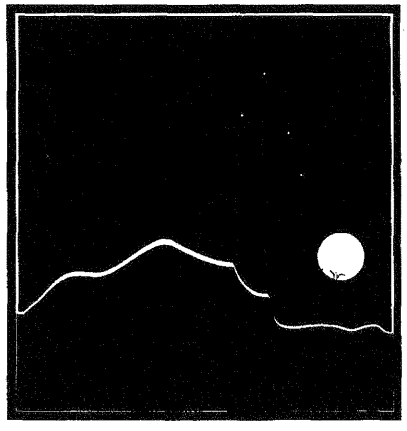
Summer nights are a great time for observing stars, perhaps on a camping trip or a picnic. My family has gone camping many times, but when I began asking my 12-year-old daughter questions about the twinkling of stars, I was startled to find that she wasn't even sure what twinkling was. At first she was confused about the difference between the terms "twinkling" and "shining,"; then she wasn't sure if she'd ever seen twinkling.

If you have a chance to get out with a youngster on a night when the stars are twinkling, it might be interesting to point out the phenomenon and ask why the stars twinkle. Is it a characteristic of the stars themselves? Some children may remember that on many nights the stars shine quite steadily. On a turbulent night, they should be able to observe that all of the stars, not just a few, twinkle. This may lead to the reasonable conclusion that the state of the atmosphere makes the difference. After I pointed out to my daughter that in our area the scintillation (twinkling) often occurs when the hot winds come off the desert, she asked if it could be caused by the heat waves. She said the heat waves quiver, so the light could quiver.

With older children, you can ask if they are aware of any similar phenomenon—my 14-year-old suggested that when you look over the top of a hot car, you can see things jumping around in the heat waves. With a younger child, you might use this as a way to demonstrate the idea that heat waves can make distant objects appear to move. Looking at distant objects through the heat rising from a candle flame also works.

It's hard for a youngster to figure out why heat waves might cause objects to appear to move. My kids eventually remembered that hot air rises and is less dense. I asked if they could think of anything else that is transparent, but has a different density than air. They suggested water, and I also suggested glass. So we tried a couple of experiments.

If you take a pair of glasses, hold them at arm's length, look at distant objects, and move the glasses to the right or left, the objects appear to



move. I explained that when light goes through something of different density, it bends. They could see that, depending on the shape and position of the area of different density, it can bend in different ways.

Younger children may not be ready for the concept of density. However, once they see hot air above a candle moving the image, you can use the glasses demonstration, saying that glasses also bend the light. In this way, they can see the image move in a controlled manner.

Even though a distant object appears to move as the glasses are moved, the sky does not appear to move. (The stars twinkle, the sky doesn't.) My daughter explained that the sky does not appear to move "because there's so much, it's all the same." Okay, so point sources appear to move, but the sky doesn't, if you are observing a reasonably uniform portion of the sky.

After pointing out that the glasses bend the light, so the position of the object appears to change as the glasses are moved, I asked what this has to do with stars twinkling. The kids were eventually able to make the connection that in the presence of turbulence, the portions of air of different density bend the light, and as the air moves, the objects appear to move.

This can be demonstrated by using a "Sharpee" or equivalent pen and making a dot on the bottom of a pan. Filling the pan with water, you can first demonstrate that heat-induced turbulence of the medium can induce the dancing of the image, much as wind shear in the atmosphere can cause twinkling. This can be shown by letting more cold water flow into the pan as you watch the dot. Then, letting the water boil, you can demonstrate how heat-induced turbulence in the water can also cause twinkling, much as convective heating in the atmosphere can.

Incidentally, there are sensors with a small field of view that look at stars and measure their apparent motion and other parameters as an indicator of the turbulence of the atmosphere. These sensors are used at test sites where the level of turbulence may have an impact on other optical systems.

So, to continue the above "poem":

Twinkle, twinkle, little sphere
Your light comes through the atmosphere.
Turbulence within the air
Makes your light bend here and there.

To those of us down here below,
Gazing at your soft white glow.
Your light appears to bounce around
And twinkle for us at the ground.

Moral of the story? First, there are nice simple demonstrations for showing kids why stars twinkle. Second, never let an engineer write a poem!

JANET SHIELDS, *an* OPN *contributing editor, is a development engineer at the Marine Physical Laboratory, Scripps Institution of Oceanography, University of California, San Diego.*