Twinkle Twinkle Little Star: Light Refraction Demonstration

Learning goals:
-Become familiar with the concept of refraction
-Understand why a star twinkles
-(Be able to connect the notion of refraction to other situations)

Materials:
-Source of steam or dust – Hot water pot, etc
-Laser pointer
-Glass of water & straw (optional)

Procedure:
Heat kettle water in advance.

Begin by asking students if they've ever seen a star twinkle. Even if none say they have, ask them to guess why they think that is. Take a minute or two to discuss this. Then tell them that you'll try to demonstrate what actually happens when a star twinkles.

So we know that stars emit light, which is what we see on Earth. However, the light that reaches us on Earth has to pass through space and the Earth's atmosphere. The latter is made up of all kinds of gases, including water vapor. So the setup we have will mimic this situation. We have a laser pointer, which we can think of as the star. We also have a kettle (or similar), which gives off water vapor, which is like our atmosphere.

Turn on the laser and shine it at a screen without steam. Then turn on the laser and shine it through the hot steam. Point out that you can actually see the laser beam oscillating in the steam along its path. Hopefully oscillations in brightness will be seen on the screen. Tell them that this effect is a result of something called **refraction**.

Explain that refraction is a result of the light beam traveling through different materials. The explanation below may help:

When a light beam passes from one substance to another (e.g., from air to water), it is bent, or "refracted", because the substances each have a different "index of refraction". The index of refraction is determined by the properties of the substance, such as its physical state (gas, water, or solid), its chemical composition, and its temperature. For example, the index of refraction of water vapor differs from that of air, and even the index of refraction of hot air differs from that of cold air. Hence, when the laser light passes through the steam (water vapor), it is refracted in many different directions, which causes variations in the brightness and location of the point of light ("twinkling").

If we have a setup showing refraction in a different way, e.g. straw in a glass of water, show that while explaining.

At the end of the explanation, explain its importance to astronomy, in that different effects of the atmosphere, etc. can make the star twinkle. Again refer to the explanation in the separate sheet for fuller description.

Wrap up by connecting the refraction of the atmosphere to other sorts of refraction, refer back to supplementary demo (straw in water, etc) as necessary.

Demonstrator's Summary – Refraction of Light

Description: Students observe the effects of atmospheric refraction by comparing an unobstructed laser light beam to one that passes through steam from a kettle of boiling water. The steam causes the laser light to vary in brightness and move around slightly, similar to the manner in which stars twinkle when viewed through Earth's atmosphere.

Physics (8^{th} Grade-Level): When a light beam passes from one substance to another (e.g., from air to water), it is bent, or "refracted", because the substances each have a different "index of refraction". The index of refraction is determined by the properties of the substance, such as its physical state (gas, water, or solid), its chemical composition, and its temperature. For example, the index of refraction of water vapor differs from that of air, and even the index of refraction of hot air differs from that of cold air. Hence, when the laser light passes through the steam (water vapor), it is refracted in many different directions, which causes variations in the brightness and location of the point of light ("twinkling").

Relation to Astronomy: In a similar manner, the light from stars must pass through turbulent gases in Earth's atmosphere on its way to Earth's surface. The different temperatures, currents, and substances in the atmosphere cause it to have slightly different indices of refraction in the same column of air. Hence, the stars appear to twinkle (vary in brightness and location) when seen from Earth's surface.

Other Information: The same effect (refraction) also explains why underwater objects appear differently when viewed from outside the water than they appear when viewed from within the water. The light rays from the object are refracted at the surface of the water (i.e., at the interface between the air and the water). Thus, an observer outside of the water will see the object in a different place (and perhaps distorted) compared to how an observer within the water will see it.