What is the problem or question? Why is this topic important?

How will the size of a primary rainbow be different, or stay the same, if the rain droplets are made with different geometry? Like a vertical paraboloid?

The shape and size of the primary rainbow is formed by a series of refraction and total internal reflection of sunlight rays on and in the spherical water droplet.
The angle between the sunlight and the final light ray that goes through the optical path may be called the deviated angle. The deviated angle has a maximum due to the restriction of total internal reflection. A maximized deviated angle then corresponds to a minimum "rainbow angle". Rainbow angle is the angle between the eyes and the final light ray. The arc-like shape of the rainbow is then produced for every water droplet on the same plane that demonstrates such angles. It is worth mentioning that due to the dependence of wavelength on the index of refraction, the rainbow angle is different for each color. From the formation of the rainbow, the shape and the size of it is determined by the total internal reflection and refraction index of the water droplet.

What is the hypothesis?

The shape of a regular-sized rain droplet in falling motion is not a sphere, instead, it undergoes a series of transformations. A more dynamic and accurate mathematical model of the surface of the rain droplets is desired for constructing a more general model of rainbow formation. Developing from such generalizations of the relationship between refraction and irregular surface, one can apply it to examine the details of other phenomena. Such as the refraction under water when the surface is in irregular motion, and the refraction on EM waves when encountering irregular surfaces constructed by gas particles. Making a rainbow as the fundamental of such a purpose has the advantage of visualizing if the outcome of the general model matches the experimental image. A vertical paraboloid may be a starting point because it has a relatively simple shape compared to other complex surfaces but contains more degree of irregularities than a sphere at the same time.

What experiment could you use to test the hypothesis?

First, use the spherical rain droplets as a reference. Replaces those droplets with enormous amounts of small spherical glasses (with known index of refraction). Make them into multiple layers so that the detector can catch all the wavelengths. Set up the light sources and a detector such that both are parallel to the layers' normal. Then, using a layer that has a circular hole at the center to cover the glasses layers. Reducing the size of the hole until the rainbow disappears on the detector. Measure the height and the distance between detector and glasses layers so that we can have the rainbow angle. Replace the glasses with a vertical paraboloid while keeping the same material. Repeat the process. Examine the difference of the image of the two rainbow. Including the size, shape, and the thickness of them.

Explain the possible results of the experiment.

If the image of the rainbow is not distorted as the size of the hole decreases, then the circular shape is maintained, then it means that the shape of a rainbow is independent of the shape of the rain droplets. If the size of the rainbow is smaller, then it means that the mathematical model is correct and may be used to expand to other complex surfaces. If the rainbow is “thicker,” then it means that the shape of the surface, particularly the increasing curvature on the edge, would increase the range of diffraction patterns.

Conclusion.

If the droplet has a vertical paraboloid volume, then the deviated angle would be increased due to the stepper slope on a paraboloid’s surface, thus having a smaller rainbow angle. A smaller angle then produces a smaller image, or rainbow. The shape will be maintained due to the same radial equivalence. The “thickness” of the rainbow may be increased due to the stepper curvature near the edge of the volume.

https://arxiv.org/pdf/1612.09563.pdf
https://sciencedemonstrations.fas.harvard.edu/presentations/florences-rainbow
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