The Rainbow Analysed

Secondary rainbow

Look again at the graphs for one and two internal reflections. The light which undergoes one internal reflection emerges at angles up to 42°, with a concentration between 40 and 42°. ‘Scattered light’, below 40°, is shown in grey.

The light which has undergone two internal reflections emerges at angles from around 51° and above, with a concentration at about that angle. So there’s no light emerging from the raindrop between those angles.

This implies that the region of sky in between the two bows should be less bright. You only see the relatively dark background cloud in this region.

Indeed there is a phenomenon known as Alexander’s dark band - named after Alexander of Aphrodisiacs who discovered it in 200AD. This is a dark area of sky which lies between the two bows of the rainbow.

This is yet another of the properties of the rainbow that can be explained by the mathematical model built up by the work of Aristotle, Descartes and Newton.

But the story of the rainbow isn’t over yet. There are further phenomena which fascinate even today’s scientists and mathematicians - for example, the so-called *supernumeraries*. If you look very carefully you can sometimes see additional, very faint coloured arcs beneath the primary bow, which are not explained by our current model. To explain those you need to revise the model and that revision involves considering light as waves rather than straight rays.

We’ve looked at a range of different models of the rainbow and the phenomena they explain.

Aristotle’s model, and his idea that all points in the raincloud return light in a cone at a fixed angle, explained the rainbow’s circular shape.

Descartes consideration of the behaviour of sunlight inside individual raindrops explains why there is a fixed angle, and also the presence of the secondary bow.

Newton discovered that different colours are refracted slightly differently and so explained the separation of the colours in the bows.

And more recent work using the wave model of light has helped to explain the presence of the supernumeraries. But rainbow enthusiasts wouldn’t be entertained if there weren’t further questions to think about and more phenomena to see.

If you can get a second internal reflection you can get a third, a fourth and so on. Usually you don’t see the bows formed from this light, because you have to look *through* the raincloud towards the sun to see them.

However, you can very occasionally see this bow in the morning mist. The rainbow has many more secrets, which are yet to be fully understood. This incredible natural phenomenon will doubtless continue to fascinate scientists and mathematicians for centuries to come.