



The Rainbow Analysed

The colours of the rainbow

It's through Descartes' model, with the help of Newton, that we can explain the colours of the rainbow. But you can sometimes see a *fainter* bow outside the main circle. The order of the colours in this *secondary* bow is reversed, with violet on the outside and red on the inside. How can this phenomenon be explained?

Remember that for the primary bow, light gets refracted as it enters the drop, and is then reflected off the back of the raindrop, ready to be refracted again as it exits. But at this exit point some light is reflected a *second* time, before being refracted as it emerges.

Descartes came up with another function relating X and Y , this time for the two internal reflections which give the secondary bow. The graph for three different colours looks like this.

Again the incoming sun's rays are equally spaced but the rays coming out are not. Look closely and you'll see that there's a concentration of emergent rays around about 51° .

But since the values of k are different for different colours, the concentration of emerging rays occurs from about 51° for red light to 54° for violet light.

For the primary bow the angle between the direction of the sunlight and the emerging ray was around about 42° . But if the light is reflected twice, the concentration of emerging rays occurs at an angle of about 51° to the sun light.

In other words, as light enters all around the front of the drop, the *second* reflection gives a *wider* cone than the one which forms the primary.

Including the different colours, you get another nest of cones emerging from the raindrop. This time, the violet cone is outermost.

This second set of cones, being outside the first set, means that the secondary bow is outside the primary. The second reflection also *reverses* the colour order of the rays.

At very high points in the cloud, the cones formed by the second reflection in the raindrops won't hit your eye.

But moving further down, there comes a point where light from the bottom edge of the violet cone reaches your eye, so this is a region of cloud where drops appear violet.

Further down again, drops appear green because it's the green cones which reach your eye.

And finally, when the drop is further down still, it's only the edge of the *innermost* red cone which reaches your eye so drops here appear red.

Cones from all the other drops combine to complete the secondary bow.