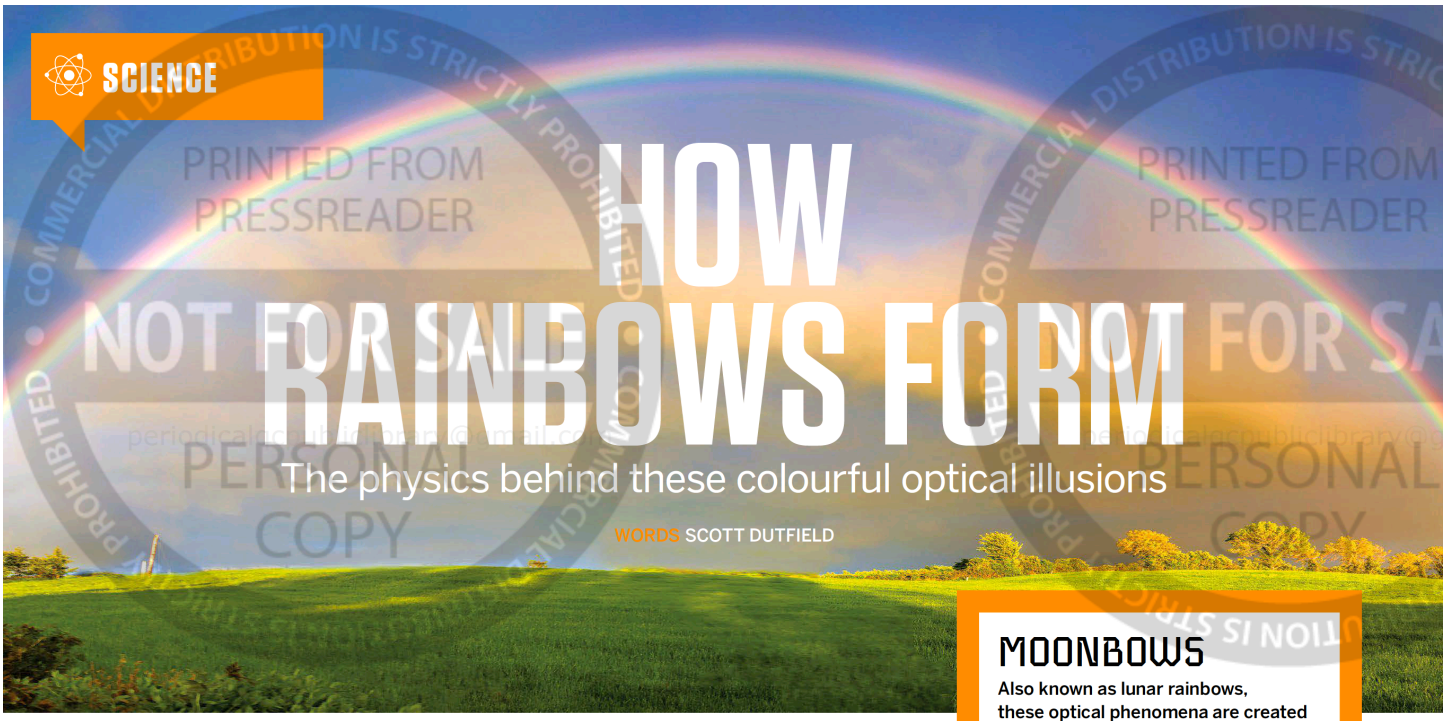
- Rainbow



SCIENCE

HOW RAINBOWS FORM

The physics behind these colourful optical illusions

WORDS SCOTT DUTFIELD

There's always one thing that can brighten up a drizzly day, and that's a rainbow. Arching across the sky, these spectacles of light are formed when moisture in the air interrupts the path of sunlight, splitting it up into all the colours of spectrum. You might be surprised to discover that raindrops aren't their assumed 'teardrop' shape, but are spherical, an important distinction when it comes to making rainbows.

A raindrop's spherical shape and increased density compared to air provide the conditions needed to bend light to the perfect rainbow-making degree. When sunlight passes through a raindrop, the direction the light is travelling is changed, known as refraction. The light is refracted as it enters the droplet, then internally reflected and sent back out the raindrop in the opposite direction, which is known as the angle of deviation.

When sunlight is refracted, it's broken up into the individual wavelengths of light. The colours range from long wavelengths of red at the top of the rainbow through the seven visible colours in the light spectrum to shorter wavelengths of violet at the bottom. When sunlight is refracted twice in raindrops it creates a double rainbow effect. The double rainbow sits around ten degrees above the primary rainbow and its colours are inverted, with red at the bottom.

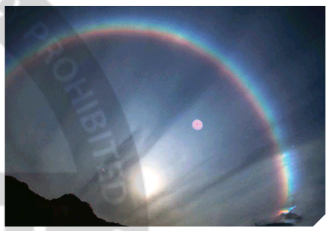
Did you know?

A record-breaking rainbow in Taipei lasted almost nine hours

The size of a rainbow is also determined by the quality of a droplet, known as its refractive index. The refractive index takes into account how well a droplet refracts light when it passes through. The higher the index, the smaller the resulting rainbow. Saltwater, for example, has a high refractive index, which means that rainbows over the ocean are typically smaller than those above freshwater lakes. But why don't we always see rainbows when it rains? Certain environmental and solar conditions need to be met for a rainbow to form. Sunlight has to hit the raindrop at precisely the right angle, which occurs when the Sun is less than 42 degrees above the horizon.

MOONBOWS

Also known as lunar rainbows, these optical phenomena are created in the same way as their daytime counterparts. In a series of reflections and refractions of light, moonbows form from sunlight that bounces off the surface of the Moon and shines down to Earth's surface as moonlight. Moonlight then passes through rain or mist and is refracted to reveal a rainbow arch. However, moonlight is much weaker than sunlight and doesn't always showcase the full spectrum of colours to the human eye. Instead, we often see a moonbow as an arch of white light.



A moonbow is a spectacular sight



Polar stratospheric clouds above the snow

RAINBOW CLOUDS

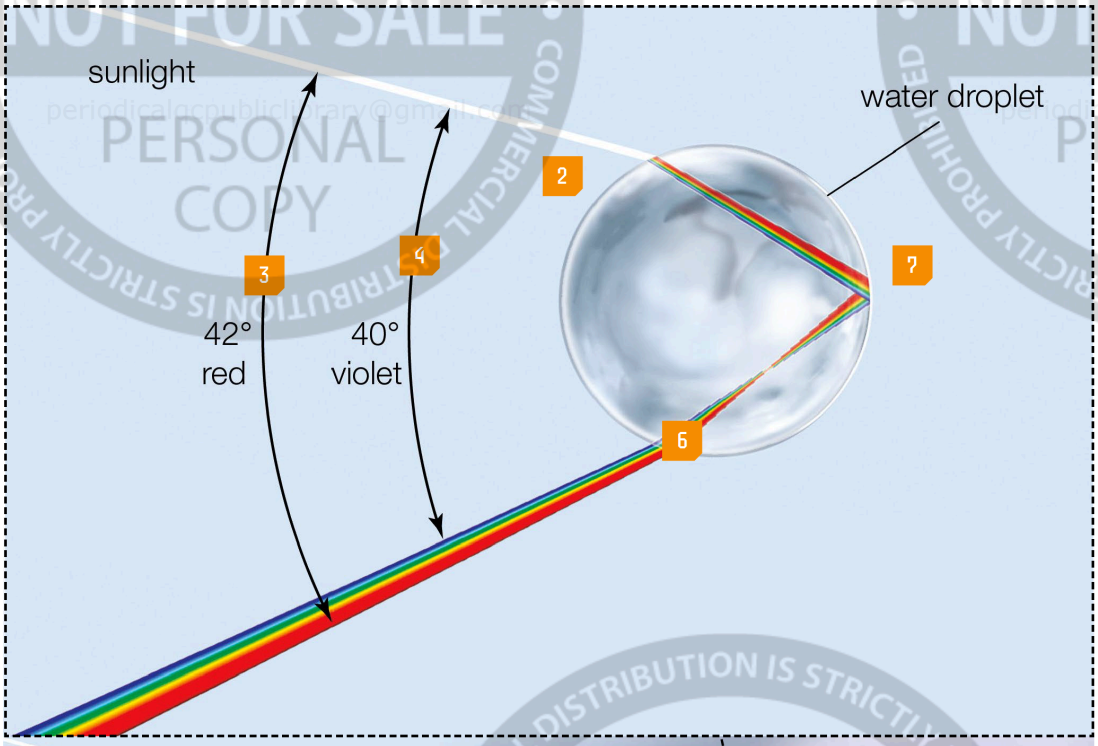
When atmospheric conditions are just right, beautiful polar stratospheric clouds can emerge. This rare phenomenon forms when clouds around 9 to 16 miles above the ground at extremely low temperatures are greeted by a rising or setting Sun. When the temperature in the stratosphere reaches below -78 degrees Celsius, tiny ice crystals, or 'supercooled droplets', form within clouds. The sunlight that passes through these clouds is scattered into the full array of colours in the visual spectrum.

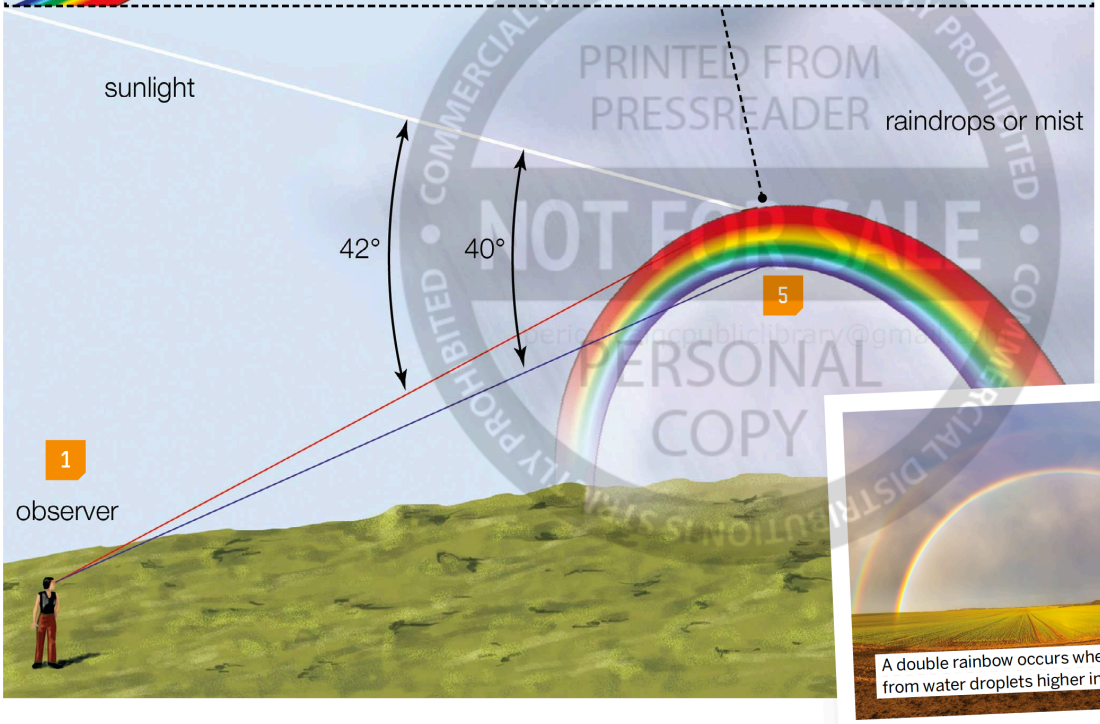
There are two categories of polar stratospheric clouds: Type I and Type II. Type I polar stratospheric clouds include ozone-depleting nitric acid, typically producing less rainbow iridescence in the clouds. Type II polar stratospheric clouds are much rarer than Type I and are made from pure ice, producing a spellbinding 'mother of pearl' rainbow hue.

DID YOU KNOW? The Greek philosopher Aristotle was the first to study the formation of rainbows in 350 BCE

COLOURS IN THE SKY

How raindrops bend light and shape rainbows





1 LIGHT SOURCE
To see a rainbow, the Sun needs to be behind the viewer.

2 WATER SOURCE
Rainbows are formed by water droplets in rain, fog or mist.

3 RED
Red wavelengths of light emerge from a raindrop at 42 degrees.

4 VIOLET
Violet wavelengths of light emerge from a raindrop at 40 degrees.

5 PLACING COLOURS
Due to the different angles colours emerge from a raindrop, rainbows have blue hues on the inside of the arc and red on the outside.

6 SEVEN COLOURS
The seven colours of the rainbow are arranged into wavelengths of light, starting with the longest, red, to the shortest, violet.

7 INTERNAL REFLECTION
A water droplet is denser than air. When light passes through, it causes the light to change direction.

A double rainbow occurs when light is refracted from water droplets higher in the sky

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