http://atoptics.co.uk/atoptics/blsky.htm

|  |  |
| --- | --- |
| Air molecules are 1000X smaller than visible light wavelengths. They act as [Rayleigh scatterers](http://atoptics.co.uk/atoptics/blsky.htm#rayleigh) and scatter blue light ~4X more strongly than longer wavelength reds. | |
| Sunlight photons of all colours stream through the air. Its molecules scatter ***a tiny proportion*** in every direction. The scattered photons have the same colour and energy.  Blue photons are more strongly scattered than greens and reds.   The scattered light makes the sky appear blue. The sky is not pure blue as it also contains a small proportion of other scattered colours.  Sunset rays pass long and deep through the lower atmosphere. They are bent and twisted around the very rim of the Earth.  The atmosphere acts as a giant lens which refracts low sunset rays into long curved paths passing through up to 40 times as much air than the rays from a high midday sun.  Air, dust, aerosols and water drops scatter and absorb the rays throughout their long passage.  Reds, yellows and golds arise because the air itself, small dust and aerosol particles smaller than the wavelengths of visible light, Rayleigh scatterers\*, scatter short wavelength blue and green rays much more strongly than longer wavelength yellow and red. The remaining direct unscattered light is dimmed but relatively enriched in reds and yellows. Absorption of specific green and blue wavelengths by ozone and water vapour molecules redden the light further. The sunset rays are sometimes reflected back and forth between clouds and the ground. All this goes to makes a spectacle seemingly painted with every colour and shade of the palette.  When the upper atmosphere contains extra fine dust from a volcanic eruption skies are reddened further.  Large dust particles and suspended water droplets scatter light differently, they are Mie scatterers\*\* and do not produce vivid red sunsets, they merely dim the sun.    \*Rayleigh scatterers  Particles much smaller than wavelengths of light scatter light in all directions. Their scattering is inversely proportional to the fourth power of the wavelength. Blue (~450 nanometer wavelength) is scattered over four times more strongly than red (~650 nm). Very small dust particles are Rayleigh scatterers. Some smoke particles are small enough also, watch smoke from a fire, it looks red or brown when viewed against a bright light but blue/white otherwise.  \*\*Mie scatterers  Particles larger than visible wavelengths scatter light predominantly forwards in the direction of the original beam. Some, like water droplets, also scatter strongly in other quite specific directions to form rainbows, fogbows, glories and coronae. With the exception of these specific directions light of different wavelengths is scattered much more equally than by Rayleigh scatterers.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  | http://www.atoptics.co.uk/images1/drkey150.jpg |  |  |  |  |  | | --- | --- | --- | --- | |  | The tiny water droplets of [clouds mists and fogs](http://www.atoptics.co.uk/droplets/clouds.htm) produce strange optical effects, they are mostly ringed and mostly brightly coloured.   "Rays" have little meaning in this domain where water droplets are so small that wave [diffraction and interference](http://www.atoptics.co.uk/droplets/light2.htm) dominate over classical journeys of light along straight lines.   |  |  | | --- | --- | |  | *Larger versions of images at;* [*corona*](http://www.atoptics.co.uk/droplets/corim6.htm)*,* [*iridescence*](http://www.atoptics.co.uk/droplets/iridim7.htm)*,* [*fogbow*](http://www.atoptics.co.uk/droplets/fogbim4.htm)*,* [*glory*](http://www.atoptics.co.uk/droplets/gloim11.htm)*,* [*Brocken Spectre*](http://www.atoptics.co.uk/droplets/glory.htm)*,* [*heiligenschein*](http://www.atoptics.co.uk/droplets/heilig.htm)*.* | | |  |     Rainbows take many forms.  Multiple bows, bows that cross, red bows, twinned bows, coloured fringes, dark bands, spokes and more.    Rainbow pictures and explanations here.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | | **flection Rainbows** | [http://www.atoptics.co.uk/rainbows/images1/rbck.gif](http://www.atoptics.co.uk/rainbows/seabow.htm) | [http://www.atoptics.co.uk/rainbows/images1/rfor.gif](http://www.atoptics.co.uk/rainbows/reflform.htm) | |  | |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | |  | | --- | |  | | http://www.atoptics.co.uk/rainbows/images1/lusk4_r1_c1.jpg | | | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | | http://www.atoptics.co.uk/rainbows/images1/lusk4_r2_c1.jpg | http://www.atoptics.co.uk/rainbows/images1/lusk4_r2_c2.jpg | http://www.atoptics.co.uk/rainbows/images1/lusk4_r2_c3.jpg | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | |  | |  | | --- | | ***Multiple Bows at Luskentyre Bay on South Harris, Scottish Hebrides.*** *Imaged by Ann Bowker (*[*Mad about Mountains*](http://www.keswick.u-net.com)*) on 10th May 2003. ©2003 Ann Bowker* |   More reflection & reflected bows [1](http://www.atoptics.co.uk/rainbows/bowim19.htm),[2](http://www.atoptics.co.uk/rainbows/bowim6.htm),[3](http://www.atoptics.co.uk/rainbows/bowim34.htm),[4](http://www.atoptics.co.uk/rainbows/rflctd.htm),[5](http://www.atoptics.co.uk/rainbows/bowim12.htm),[6](http://www.atoptics.co.uk/rainbows/bowim47.htm)  There are at least *four* rainbows in the scene at left. The strangely oriented bow curving between the primary and secondary is a primary 'reflect**ion** rainbow' [produced](http://www.atoptics.co.uk/rainbows/reflform.htm) by sunlight beaming upwards after reflection from calm water or wet sand. In this instance the sun's rays were reflected from another bay behind the camera.  And the fourth bow? Look in the wet sand. There is a fragment of bow. This is a '[reflect**ed** rainbow](http://www.atoptics.co.uk/rainbows/rflctd.htm)'.    The Scottish Western Isles are favoured places for reflection bows. The prevailing warm south westerlies from the Atlantic Ocean bring frequent showers of fine rain interspersed by skies of exceptional purity whose sunlight is reflected in the many bays and inlets.  More reflection bows [1](http://www.atoptics.co.uk/rainbows/bowim19.htm),[2](http://www.atoptics.co.uk/rainbows/bowim34.htm). | |  | |  |  |  | | --- | --- | --- | | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | | http://www.atoptics.co.uk/rainbows/images1/mrefbw1_r1_c1.jpg | http://www.atoptics.co.uk/rainbows/images1/mrefbw1_r1_c2.jpg | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | | http://www.atoptics.co.uk/rainbows/images1/mrefbw1_r2_c1.jpg | http://www.atoptics.co.uk/rainbows/images1/spacer.gif | |  | The centres of reflection bows are at the same altitude as the sun - the *anthelic point*. This is the same distance *above* the horizon as the centres of normal bows are **below** it at the *antisolar point*.   The normal bow and its corresponding reflection bow intersect at the horizon.  Reflection bows are usually brightest when the sun is low because then its light is reflected most strongly from water surfaces. The normal and reflection bows draw closer together as the sun gets lower.   The source of the reflected light is usually water behind you, i.e. sunwards. It *can* be in front of you but then only the base of the reflected bow will be seen. | |  | |

here are at least four rainbows in the scene at left. The strangely oriented bow curving between the primary and secondary is a primary 'reflection rainbow' produced by sunlight beaming upwards after reflection from calm water or wet sand. In this instance the sun's rays were reflected from another bay behind the camera.

And the fourth bow? Look in the wet sand. There is a fragment of bow. This is a 'reflected rainbow'.

The Scottish Western Isles are favoured places for reflection bows. The prevailing warm south westerlies from the Atlantic Ocean bring frequent showers of fine rain interspersed by skies of exceptional purity whose sunlight is reflected in the many bays and inlets.

More reflection bows 1,2.

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http://www.atoptics.co.uk/rainbows/images1/shim18.gif