Supplementary Information 1:
Twinned rainbow observations of Alexander Haußmann

(omitting May 11th, 2012, which is subject of the main text)

Original image	Processed image (unsharp masked)

08.08.1997, 17:35 CEST, Hörlitz (51.53° N, 13.95° E), Sun elevation: 27.2°

29.03.2007, 17:57 CEST, Regensburg (49.02° N, 12.10° E), Sun elevation: 15.5°

11.07.2008, 17:49 CEST, Dresden (51.06° N, 13.77° E), Sun elevation: 29.6°

15.05.2011, 18:17 CEST, Hörlitz (51.53° N, 13.95° E), Sun elevation: 21.4°

11.05.2014, 18:42 CEST, Hörlitz (51.53° N, 13.95° E), Sun elevation: 16.8°

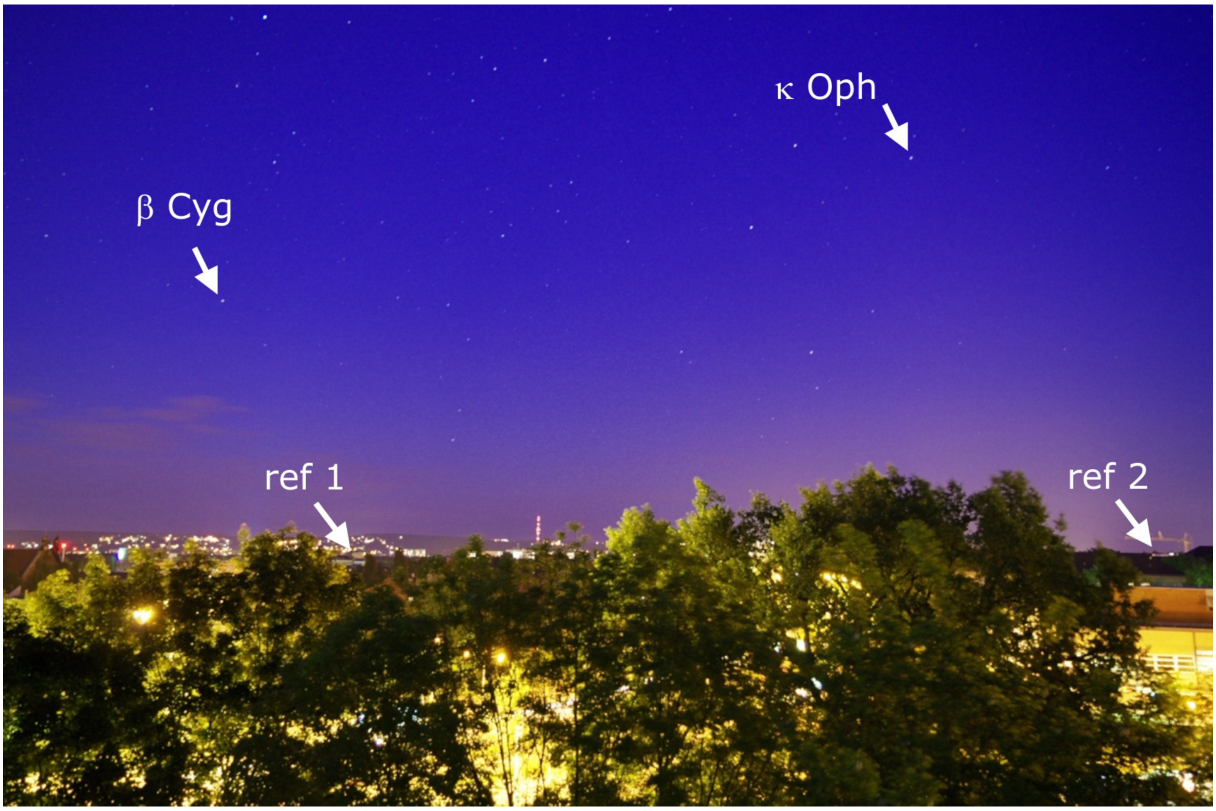
Supplementary information 2:
Earlier development stages of the rainbow display, May 11th, 2012, Dresden

17.35.08 CEST, lens: Pentax DA 18-55 mm at 18 mm

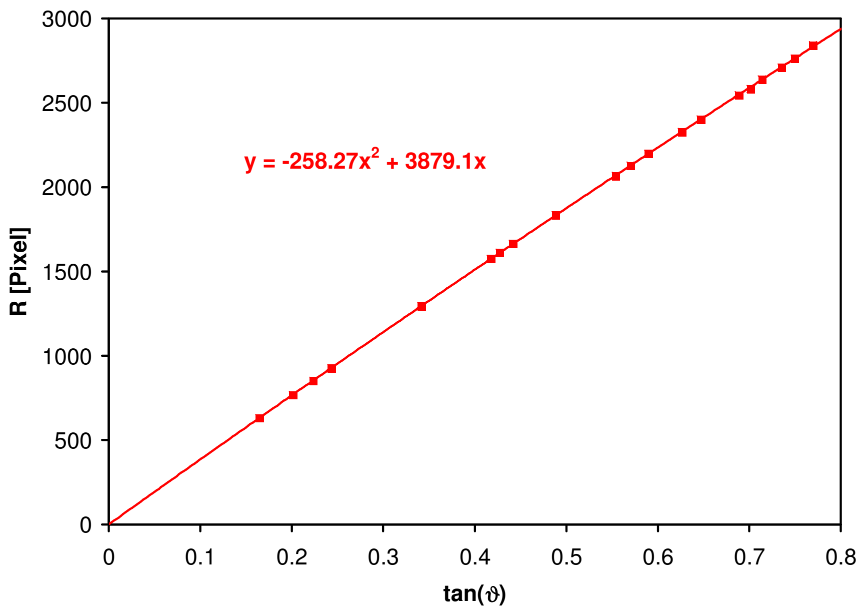
Cropped and processed version of the above picture (unsharp masked, contrast enhanced). The upper branch of the twinned primary is caused by nearby drops as their glittering and the visibility against the eaves gutter and wall indicate.

17.37.44 CEST, lens: Zenitar 16 mm. This picture was recorded after the first twinning involving nearby drops had vanished (together with the rainfall at the observer's location) and before the second prominent twinning (as discussed in the main text) did appear. At this intermediate stage, the display looked more like an ordinary rainbow with a pronounced first supernumerary rather than a twinned bow.

Supplementary information 3:
Image calibration and reference points



Starfield image serving two purposes: (a) lens calibration (Eq. (1)) and (b) landmark localization, recorded May 14th, 2012, 22:12:15 CEST (center time of exposure) from the same window as the twinned rainbow photograph.



Lens calibration from the above photograph, using the position analysis of 20 stars and performing second-degree polynomial regression over tan(ϑ), with ϑ being the field angle and R the distance from the sensor center.

The negative sign of the quadratic coefficient corresponds to a barrel distortion, which is common for zoom lenses at the low end of the zoom range. Ideal gnomonic projection would yield a straight line.

The calibration image was oriented by the two stars:

β Cyg: $h = 13.86°$, $\alpha = 62.38°$
κ Oph: $h = 22.99°$, $\alpha = 104.11°$

resulting in the data set:

Elevation of the optical axis: 9.1°
Azimuth of the optical axis: 85.5°
Rotation around optical axis: -1.0° (image rotated clockwise out of horizontal)

From this, the positions of the reference points can be calculated:

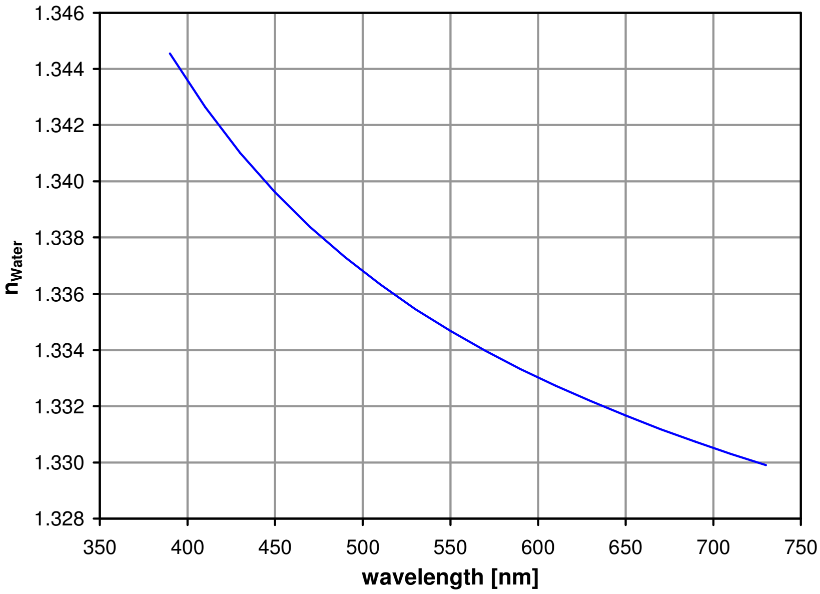
ref 1: $h = -0.3°$, $\alpha = 70.5°$
ref 2: $h = 0.7°$, $\alpha = 115.6°$

Details on how the orientation parameters are determined from the reference points and the coordinate transformations are carried out can be found in [21].

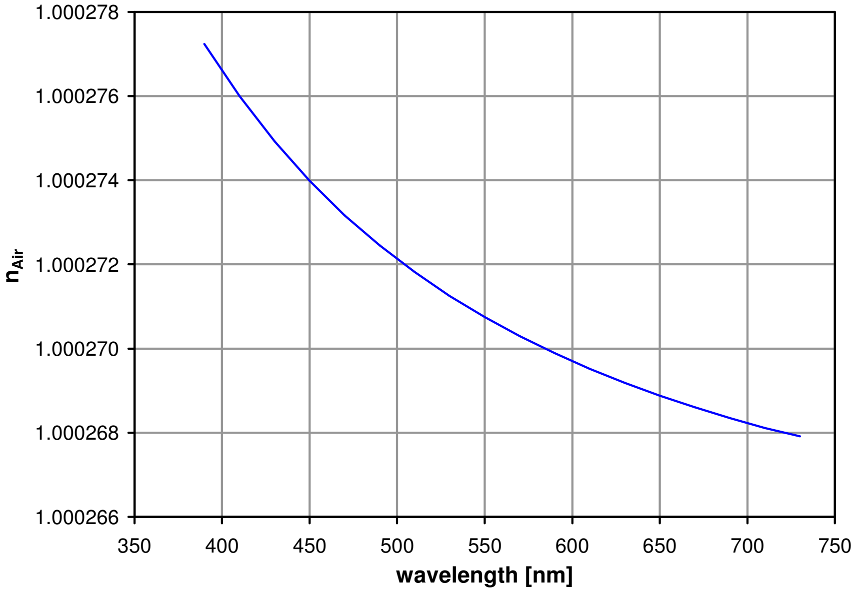
Unsharp masked and contrast expanded version of the rainbow photograph, $R = 3879.1 \cdot \tan(\vartheta) - 258.27 \cdot \tan^2(\vartheta)$

Reconstructed ideal gnomonic projection of the photograph, i.e. transformed into $R = 3879.1 \cdot \tan(\vartheta)$.

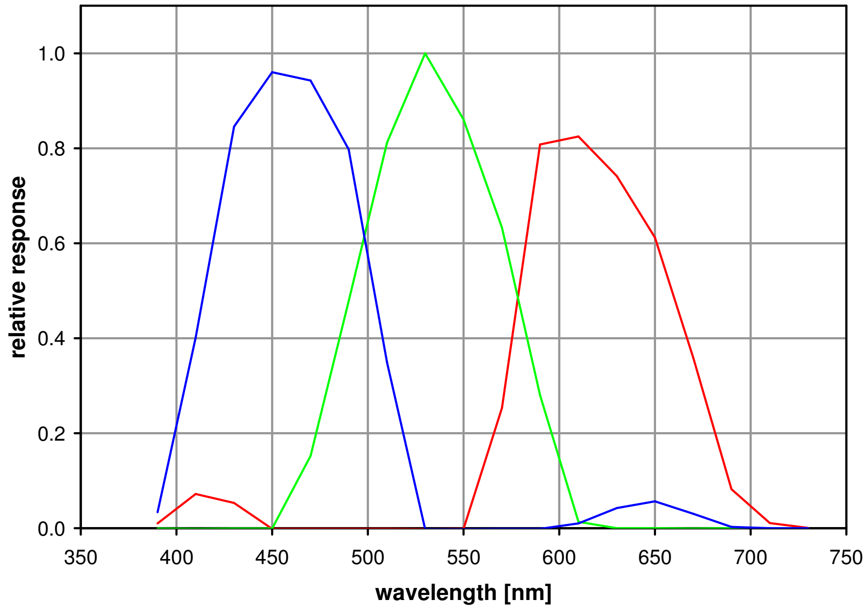
Supplementary information 4:
Refractive indices, camera sensitivity response, solar spectrum



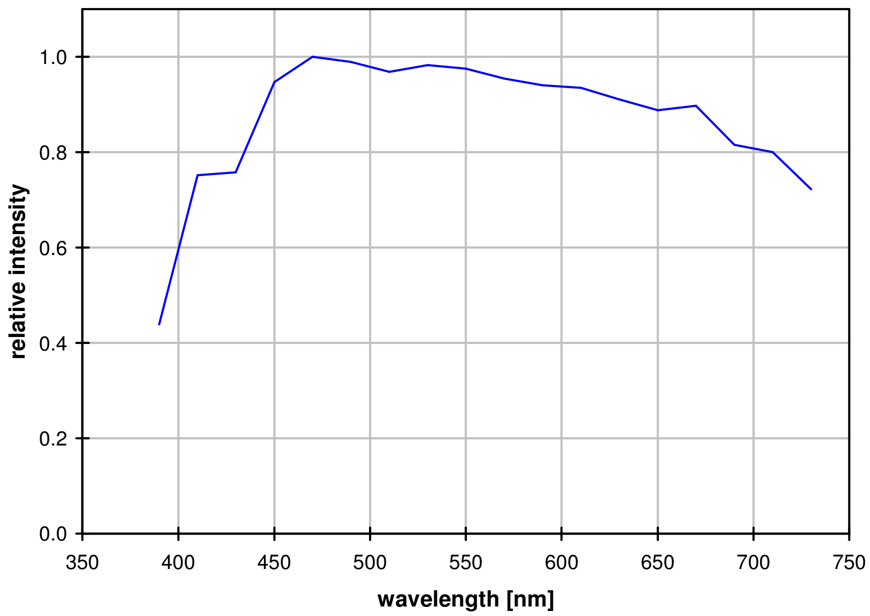
Refractive index of water at 20 °C with respect to vacuum, calculated from [26].



Refractive index of air at 20 °C with respect to vacuum (air pressure 998 hPa, relative humidity 80%, 450 ppm CO_2*), calculated from [27].*



Sensitivity response of the Pentax K-5 camera sensor measured with a Shimadzu UVPC 3100 spectrophotometer as monochromatic light source, interpolated to the 18 wavelengths used in the calculations.



Solar spectrum for an air mass of 1.5 (from [28]), interpolated to the 18 wavelengths used in the calculations.