



Light and color in the open air—introduction to the feature issue

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This feature issue reports recent progress in scientific understanding of optical phenomena in the natural world, visible to the naked eye. The issue contains papers largely arising from presentations given at the 12th International Conference on Light and Color in Nature, held at the University of Granada from 31 May to 3 June 2016. © 2017 Optical Society of America

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This feature issue is all about optical phenomena that can be seen in the natural world. From sky colors to halos, the common theme is beautiful and scientifically interesting phenomena that can be seen with the naked eye. Most papers in this feature issue are based on presentations given at the 12th International Conference on “Light and Color in Nature” held at the University of Granada from 31 May to 3 June 2016. These meetings, uniquely focused on natural optical phenomena, have been held approximately every three years since being initiated by David Lynch in 1978 [1]. Since then, approximately 251 scientific papers have been published from the Light and Color meetings in OSA journals (mostly *Applied Optics*, including 24 papers in this issue) [2]. These papers cover an exceptionally wide gamut ranging from optical and radiative transfer modeling, to digital image analysis, and to our science’s origins in naked-eye observations.

Marcel Minnaert’s 1954 book “The Nature of Light and Colour in the Open Air” [3] is held in great esteem by the participants of these meetings because this book is full of lucid explanations of numerous optical phenomena. By modern standards, it contains very few photographs, and even these are not in color. Of course, black-and-white photographs cannot do justice to colorful phenomena such as rainbows. Even in the 1960s and 1970s, color photographs of phenomena such as glories were extremely rare, partly because air travel was infrequent and partly because people generally did not carry cameras with them at all times.

Smartphones with built-in cameras are now becoming ubiquitous, thus increasing the chances of capturing images of rare optical phenomena. Furthermore, the increasing use of social media and photo-sharing sites means that such images can become widely available, rather than a single print being kept in a photograph album by the photographer. An internet

search for an unusual phenomenon such as “lunar rainbow” can lead you to many impressive images—even if some of them actually show the moon surrounded by a 22° ice halo! Although such confusion about the differences between rainbows, coronas, halos and glories is understandable for nonscientists, fortunately various web sites now provide comprehensive scientific information on these topics. The meeting in Granada paid tribute to the efforts of Les Cowley in developing his impressive “Atmospheric Optics” web site (www.atoptics.co.uk) which provides an indispensable guide consisting of hundreds of carefully collated images and, more importantly, detailed scientific explanations of numerous phenomena.

The feature issue’s scientific papers are a natural outgrowth of this public fascination with such colorful (and often evanescent) optical displays, many of which have been studied for decades by our contributors and colleagues. Far from being of peripheral interest, these phenomena form the historical foundations of optics and are part of its ongoing construction. Because the optics of the natural world both informs and delights, we offer these collected papers as our latest scientific contribution to its centuries-long building effort.

The papers in this issue offer new insights into optical phenomena you may think are completely understood, as well as ones you did not even know existed. Reading them will take you on an optical tour from astronomical objects, through the entire atmosphere, and down to the ground and into the water around us. Topics include our own Sun and Moon, stars, sky and cloud colors and polarization, rainbows, halos, coronas, the green flash, mirages, shadows, optics of dust, soil, and rocks, and optical effects on and in water.

We express gratitude to all the authors of papers in this issue, to all the presenters at the meeting including those who were unable to archive their work here, and to the staff

at the Optical Society of America Publications Office who helped to create this issue. We gratefully acknowledge the service of the conference organizing committee, Professor Javier Hernández-Andrés and the University of Granada for hosting us in 2016, and the U. S. National Science Foundation for travel support.

REFERENCES

1. Meetings in this series include: Meteorological Optics, Keystone, Colorado, 1978 (David Lynch); Atmospheric Optics, Incline Village, Nevada, 1983 (William Mach and Alistair Fraser); Meteorological Optics, Honolulu, Hawaii, 1986 (David Lynch); Light and Color in the Open Air, Washington, D.C., 1990 (Robert Greenler); Light and Color in the Open Air, State College, Pennsylvania, 1993 (Craig Bohren); Light and Color in the Open Air, Santa Fe, New Mexico, 1997 (Ken Sassen); Meteorological Optics, Boulder, Colorado, 2001 (Stanley Gedzelman); Atmospheric/Meteorological Optics, Bad Honnef, Germany, 2004 (Michael Vollmer); Light and Color in Nature, Bozeman, Montana, 2007 (Joseph Shaw); Light and Color in Nature, St. Mary's City, Maryland, 2010 (Charles Adler); Light and Color in Nature, Fairbanks, Alaska, 2013 (Ken Sassen); Light and Color in Nature, Granada, Spain, 2016 (Javier Hernández-Andrés).
2. Previous feature issues in this series include: J. Opt. Soc. Am. **69**(8), 1051–1132; 1178–1180 (1979); J. Opt. Soc. Am. **73**(12), 1622–1664 (1983); J. Opt. Soc. Am. A **4**(3), 558–620 (1987); Appl. Opt. **30**(24), 3381–3552 (1991); Appl. Opt. **33**(21), 4535–4760 (1994); Appl. Opt. **37**(9), 1425–1588 (1998); Appl. Opt. **42**(3), 307–525 (2003); Appl. Opt. **44**(27), 5623–5762 (2005); Appl. Opt. **47**(34), H1–H224 (2008); Appl. Opt. **50**(28), LC1-LC2 and F1–F171 (2011); Appl. Opt. **54**(4), LC1-LC2 and B1-B265 (2015).
3. M. Minnaert, *Light and Color in the Outdoors* (originally published as *Light and Color in the Open Air*), Springer-Verlag, New York, 1993.