

Chapter 7

Armadillos dancing against a swollen Moon

(vision)

Here are the references and web links for the stories in the book.

Recently added references are highlighted. For updates to those stories and for all the new stories, go to

<http://www.flyingcircusofphysics.com/News/NewsDetail.aspx?NewsID=43>

July 2009

7.1 Enlarging the Moon

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

http://www.geocities.com/csh_home/picture_july2005.html Discussion

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Boring, E., “The Moon illusion,” *American Journal of Physics*, 11, No. 2, 55-60 (April 1943)
- Dadourian, H. M., “The Moon illusion,” *American Journal of Physics*, 14, 65-66 (1946)
- Boring, E. G., “The perception of objects,” *American Journal of Physics*, 14, 99-107 (1946)
- Minnaert, M., *Light and Colour in the Open Air*, Dover, 1954, pages 151-166
- Kaufman, L., and I. Rock, “The Moon illusion, I,” *Science*, 136, 953-961 (1962)
- Rock, I., and L. Kaufman, “The Moon illusion, II,” *Science*, 136, 1023-1031 (1962)
- Kaufman, L., and I. Rock, “The Moon illusion,” *Scientific American*, 207, No. 1, 120-130 (July 1962)

- Restle, F., “Moon illusion explained on the basis of relative size,” *Science*, 167, 1092-1096 (1970)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 55-62
- Kaufman, L., *Perception: The World Transformed*, Oxford University Press, 1979, pages 322-332
- Owens, D. A., “The resting state of the eyes,” *American Scientist*, 72, 378-387 (1984), see page 385
- Rock, I., *Perception*, Scientific American Library, 1984, pages 26-30
- Wolbarsht, M. L., and G. R. Lockhead, “Moon illusion: a new perspective,” *Applied Optics*, 24, No. 12, 1844-1847 (15 June 1985)
- McCready, D., “Moon illusions redescribed,” *Perception & Psychophysics*, 39, No. 1, 64-72 (1986)
- Enright, J. T., “Manipulating stereopsis and vergence in an outdoor setting: Moon, sky and horizon,” *Vision Research*, 29, No. 12, 1815-1824 (1989)
- Lockhead, G. R., and M. L. Wolbarsht, “Toying with the Moon illusion,” *Applied Optics*, 30, No. 24, 3504-3507 (20 August 1991)
- Higashiyama, A., “anisotropic perception of visual angle: implications for the horizontal-vertical illusion, overconstancy of size, and the moon illusion,” *Perception & Psychophysics*, 51, No. 3, 218-230 (1992)
- Minnaert, M., *Light and Color in the Outdoors*, translated and revised by L. Seymour, Springer-Verlag, 1993, pages 171-178
- Reed, C. F., “The immediacy of the moon illusion,” *Perception*, 25, 1295-1300 (1996)
- Egan, F., “The Moon illusion,” *Philosophy of Science*, 65, No. 4, 604-623 (December 1998)
- Kaufman, L., and J. H. Kaufman, “Explaining the moon illusion,” *PNAS*, 97, No. 1, 500-505 (4 January 2000)
- Bower, B., “The moon also rises---and assumes new sizes,” *Science News*, 157, 22 (8 January 2000)
- Parks, T. E., “The mirror- (and the moon-) illusion,” *Perception*, 30, No. 7, 899 (2001)
- Ross, H., and C. Plug, *The Mystery of the Moon Illusion*, Oxford University Press, 2002
- Redding, G. M., “A test of size-scaling and relative-size hypotheses for the moon illusion,” *Perception & Psychophysics*, 64, No. 8, 1281-1289 (2002)
- Sterzer, P. and G. Rees, “Perceived size matters,” *Nature Neuroscience*, 9, No. 3, 302-304 (March 2006)

- Murray, S. O., H. Boyaci, and D. Kersten, “The representation of perceived angular size in human primary visual cortex,” *Nature Neuroscience*, 9, No. 3, 429-434 (March 2006)
- MacEvoy, S. P., and D. Fitzpatrick, “Visual physiology: perceived size looms large,” *Current Biology*, 16, No. 9, R330-R332 (9 May 2006)
- Higashiyama, A., and K. Adachi, “Perceived size and perceived distance of targets viewed from between the legs: Evidence for proprioceptive theory,” *Vision Research*, 46, 3961-3976 (2006)

7.2 Shape of the sky

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Miller, A., and H. Neuberger, “Investigations into the apparent shape of the sky,” *Bulletin of the American Meteorological Society*, 26, 212-216 (June 1945)
- Stork, D. G., and L. Falk, (letter) “The optics of the crescent Moon,” *American Journal of Physics*, 56, No. 7, 583 (July 1988)
- Scholkopf, B., “The moon tilt illusion,” *Perception*, 27, 1229-1232 (1998)

See also the references to the preceding item.

7.3 Decapitation with the blind spot

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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<http://ourworld.compuserve.com/homepages/cuius/idle/percept/blindspot.htm> Diagram locating the blind spot, plus discussion

<http://www.ophtasurf.com/en/blindspot.htm> Use the dot and X to find your blind spot

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Stong, C. L., “Amateur Scientist,” *Scientific American*, 198, 100-109 (January 1958)
- Richards, W., “Obituary of Dr. H.-L. Teuber,” *Vision Research*, 18, 357 (1978)
- Rushton, W. A. H., “King Charles II and the blind spot,” *Vision Research*, 19, 225 (1979)
- Fineman, M., *The Inquisitive Eye*, Oxford University Press, 1981, pages 22-24
- Reeves, A., letter, *Vision Research*, 22, 711 (1982)
- Bridgeman, B., and D. Staggs, “Plasticity in human blindsight,” *Vision Research*, 22, 1199-1203 (1982)
- Walker, J., “‘Floaters’: visual artifacts resulting from blood cells in front of the fovea” in “The Amateur Scientist,” *Scientific American*, 246, 150-162 (April 1982)
- Kawabata, N., “Global interactions in perceptual completion at the blind spot,” *Vision Research*, 23, 275-279 (1983)
- Kawabata, N., “Perception at the blind spot and similarity grouping,” *Perception & Psychophysics*, 36, 151-158 (1984)
- Andrews, P. R., and F. W. Campbell, “Images at the blind spot,” *Nature*, 353, 308 (26 September 1991)
- Ramachandran, V. S., and R. L. Gregory, “Perceptual filling in or artificially induced scotomas in human vision,” *Nature*, 350, 699-702 (25 April 1991)
- Sanny, J., “Measuring the diameter of your blind spot,” *Physics Teacher*, 37, 348-349 (September 1999)
- Zur, D., and S. Ullman, “Filling-in of retinal scotomas,” *Vision Research*, 43, 971-982 (2003)
- Farkas, N., K. M. Donnelly, P. N. Henriksen, and R. D. Ramsier, “The blind spot: re-educating ourselves about visual images,” *Physics Education*, 39, No. 3, 294-297 (May 2004)

- Spillmann, L., T. Otte, K. Hamburger, and S. Magnussen, “Perceptual filling-in from the edge of the blind spot,” *Vision Research*, 46, 4252-4257 (2006)

Related references

- He, S., and W. L. Davis, “Filling-in at the natural blind spot contributes to binocular rivalry,” *Vision Research*, 41, 835-840 (2001)
- Tripathy, S. P., and B. T. Barrett, “Misperceptions of trajectories of dots moving through the blind spot,” *Perception*, 35, 137-142 (2006)

7.4 Gray networks in the morning, dashing specks in the daylight

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Stong, C. L., “Amateur Scientist,” *Scientific American*, 198, 100-108 (January 1958)
- Fireman, R. A., E. Prenner, and H. Norden, in “The Amateur Scientist,” C. L. Stong, editor, *Scientific American*, 198, 122 and 124 (June 1958)
- Stong, C. L., “The Amateur Scientist,” *Scientific American*, 201, 249-?? (September 1959)
- Helmholtz, H. von, *Physiological Optics*, volume 1, J. P. C. Southall, editor, Dover, 1962, pages 212ff
- Stong, C. L., “The Amateur Scientist,” *Scientific American*, 221, 134 (October 1969)
- Cornsweet, T. N., *Visual Perception*, Academic Press, 1970, pages 406ff
- Sharpe, C. R., “The visibility and fading of thin lines visualized by their controlled movement across the retina,” *The Journal of Physiology*, 222, 113-134 (1972)
- Padgham, C. A., and J. E. Saunders, *The Perception of Light and Colour*, G. Bell & Sons, 1975, pages 28-29

- Drysdale, A. E., “The visibility of retinal blood vessels,” *Vision Research*, 15, 813-818 (1975)
- Wyatt, H. J., “Purkinje's methods for visualizing the internal retinal circulation: a look at the source,” *Vision Research*, 18, 875-877 (1978)
- Loebel, M., and C. E. Riva, “Macular circulation and the flying corpuscles phenomenon,” *Ophthalmology*, 85, 911-917 (September 1978)
- Sinclair, S. H., M. Loebel and C. E. Riva, “Blue field entoptic phenomenon in cataract patients,” *Arch. Ophthalmology*, 97, 1092-1095 (1979)
- Riva, C. E., J. J. Kelley, S. H. Sinclair and M. Loebel, “Optical transmission of cataractous lens at 430 nm and blue field entoptoscopy,” *Vision Research*, 19, 1181-1183 (1979)
- Riva, C. E., and B. Petrig, “Blue field entoptic phenomenon and blood velocity in the retinal capillaries,” *Journal of the Optical Society of America*, 70, No. 10, 1234-1238 (October 1980)
- Oldendorf, W., “Seeing inside your eye,” *Science Digest*, ??, 92-93 (January/February 1981)
- Walker, J., “Floaters': visual artifacts resulting from blood cells in front of the fovea” in “The Amateur Scientist,” *Scientific American*, 246, 150-162 (April 1982)
- Tulunay-Keesey, U., “Fading of stabilized retinal images,” *Journal of the Optical Society of America*, 72, No. 4, 440-447 (April 1982)
- Burbeck, C. A., and D. H. Kelly, “Role of local adaptation in the fading of stabilized images,” *Journal of the Optical Society of America, Series A*, 1, 216-220 (February 1984)
- Arend, L. E., and G. T. Timberlake, “What is psychophysically perfect image stabilization? Do perfectly stabilized images always disappear?” *Journal of the Optical Society of America, A* 3, 235-241 (1986)
- Ditchburn, R. W., “What is psychophysically perfect image stabilization? Do perfectly stabilized images always disappear?: Comment,” *Journal of the Optical Society of America A*, 4, 405-406 (1987); L. E. Arend and G. T. Timberlake, reply to comment, pages 407-408
- Sheehan, W., and T. A. Dobbins, (letter) “Lowell's spokes on Venus explained,” *Sky & Telescope*, 104, No. 4, 12-13 (October 2002)
- Sheehan, W., “Venus spokes: An explanation at last?” (28 June 2002) news item available at Skyandtelescope.com

7.5 Floaters and other spots in your eye

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Lee, N., C. R. Cavonius, J. Billings, and T. Nickson, (letters) “Seeing things,” in “The Last Word,” New Scientist, ??, inside back cover (??)
- Fireman, R. A., E. Prenner, and H. Norden, ?? “The Amateur Scientist,” C. L. Stong, editor, Scientific American, 198, 122-?? (June 1958)
- Helmholtz, H. von, *Physiological Optics*, J. P. C. Southall, editor, Dover, 1962, volume 1, pages 204ff
- White, H. E., and P. Levatin, “Floaters' in the eye,” Scientific American, 206, No. 6, 119-127 + 200 (June 1962)
- Crawford, F. S., Jr., *Waves* (Berkeley Physics Course, volume 3), McGraw-Hill, 1968, page 530
- Walker, J., “Floaters': visual artifacts resulting from blood cells in front of the fovea” in “The Amateur Scientist,” Scientific American, 246, 150-162 (April 1982) ??correct this: floaters are not in the fovea
- Walker, J., “The Amateur Scientist,” Scientific American, 247, 206 (September 1982); see page 216
- Edge, R. D., “The optics of the eye lens,” Physics Teacher, 27, 392-393 (May 1989)
- Diamond, J. P., “When are simple flashes and floaters ocular emergencies,” Eye, 6, Part 1, 102-104 (1992)
- Navarro, R., and M. A. Losada, “Shape of stars and optical quality of the human eye,” Journal of the Optical Society of America A, 14, No. 2, 353-359 (February 1997)
- Keepports, D., “Estimating the size of blood cells by staring into space,” Physics Teacher, 36, 58 (January 1998)

7.6 Streetlight halos, candle glow, star images

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Minnaert, M., *Light and Colour in the Open Air*, Dover, 1954, pages 221-223
- Helmholtz, H. von, *Physiological Optics*, volume 1, J. P. C. Southall, editor, Dover, 1962, pages 224-225
- Boynton, R. M., and F. J. J. Clarke, "Sources of entoptic scatter in the human eye," *Journal of the Optical Society of America*, 54, No. 1, 110-119 (January 1964)
- Mellerio, J., and D. A. Palmer, "Entopic halos," *Vision Research*, 10, 595-599 (1970)
- Mellerio, J., and D. A. Palmer, "Entopic halos and glare," *Vision Research*, 12, 141-143 (1972)
- Miller, D., and G. Benedek, *Intraocular Light Scattering. Theory and Clinical Application*, Charles C. Thomas, Publisher, 1973
- Schaefer, B. E., "Glare and celestial visibility," *Publications of the Astronomical Society of the Pacific*, 103, 645-660 (July 1991)
- Minnaert, M., *Light and Color in the Outdoors*, translated and revised by L. Seymour, Spring-Verlag, 1993, pages 245-247
- Beckman, C., O. Nilsson, and L.-E. Paulson, "Intraocular light scattering in vision, artistic painting, and photography," *Applied Optics*, 33, No. 21, 4749-4753 (20 July 1994)
- Dan, N. G., "Visual dysfunction in artists," *Journal of Clinical Neuroscience*, 10, No. 2, 168-170 (2003)

7.7 Phosphenes --- psychedelic displays

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Helmholtz, H. von, *Physiological Optics*, volume 2, J. P. C. Southall, editor, Dover, 1962, pages 256-257
- Oster, G., "Optical Art," *Applied Optics*, 4, No. 11, 1359-1369 (November 1965), see pages 1367-1368
- Oster, G., "Phosphenes," *Scientific American*, 222, No. 2, 82-87 (February 1970)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 242-243
- Remole, A., "Subjective patterns in a flickering field: binocular vs. monocular observation," *Journal of the Optical Society of America*, 63, No. 6, 745-748 (June 1973)
- Dobelle, W. H., M. G. Mladejovsky and J. P. Girvin, "Artificial vision for the blind: electrical stimulation of visual cortex offers hope for a functional prosthesis," *Science*, 183, 440-444 (1974)
- "Seeing by phosphenes," *Scientific American*, 230, 45 (March 1974)
- Dobelle, W. H., and M. G. Mladejovsky, "Phosphenes produced by electrical stimulation of human occipital cortex, and their application to the development of a prosthesis for the blind," *Journal of Physiology*, 243, 553-576 (1974)
- Young, R. S. L., R. E. Cole, M. Gamble and M. D. Rayner, "Subjective patterns elicited by light flicker," *Vision Research*, 15, 1291-1293 (1975)
- Dobelle, W. H., M. G. Mladejovsky and J. R. Evans, "'Braille' reading by a blind volunteer by visual cortex stimulation," *Nature*, 259, 111-112 (15 January 1976)
- Tyler, C. W., "Some new entoptic phenomena," *Vision Research*, 18, 1633-1639 (1978)
- Lovsund, P., P. A. Oberg, and S. E. G. Nilsson, "Magneto- and electrophosphenes: a comparative study," *Medical & Biological Engineering & Computing*, 18, No. 6, 758-764 (1980)
- Walker, J., "About phosphenes: luminous patterns that appear when the eyes are closed" in "The Amateur Scientist," *Scientific American*, 244, 174-186 (May 1981)

- Walker, J., “The Amateur Scientist,” *Scientific American*, 245, 172 (December 1981), see pages 176 and 178
- Grusser, O.-J., U. Grusser-Cornehls, R. Kusel, and A. W. Przybyszewski, “Responses of retinal ganglion cells to eyeball deformation: a neurophysiological basis for 'pressure phosphenes',” *Vision Research*, 29, 181-194 (1989)
- Steidley, K. D., “The radiation phosphene,” *Vision Research*, 30, 1139-1143 (1990)
- Marg, E., “Magnetostimulation of vision: direct noninvasive stimulation of the retina and the visual brain,” *Optometry and Vision Science*, 68, No. 6, 427-440 (1991)
- Lindenblatt, G., and J. Silny, “Electrical phosphenes: on the influence of conductivity inhomogeneities and small-scale structures of the orbita on the current density threshold of excitation,” *Medical & Biological Engineering & Computing*, 40, No. 3, 354-359 (May 2002)
- Attwell, D., “Interaction of low frequency electric fields with the nervous system: the retina as a model system,” *Radiation Protection Dosimetry*, 106, No. 4, 341-348 (2003)
- Taki, M., Y. Suzuki, and K. Wake, “Dosimetry considerations in the head and retina for extremely low frequency electric fields,” *Radiation Protection Dosimetry*, 106, No. 4, 349-356 (2003)
- Taki, M., Y. Suzuki, and K. Wake, “Dosimetry considerations in the head and retina for extremely low frequency electric fields,” *Radiation Protection Dosimetry*, 106, No. 4, 349-356 (2003)
- Krammer, T., K. Puls, M. Erb, and W. Grodd, “Transcranial magnetic stimulation in the visual system. II. Characterization of induced phosphenes and scotomas,” *Experimental Brain Research*, 160, 129-140 (2005)
- Cervetto, L., G. C. Demontis, and C. Gargini, “Cellular mechanisms underlying the pharmacological induction of phosphenes,” *British Journal of Pharmacology*, 150, 383-390 (2007)
- Sannita, W. G., L. Narici, P. Picozza, “Positive visual phenomena in space: A scientific case and a safety issue in space travel,” *Vision Research*, 46, 2159-2165 (2006)
- Clark, S., “Light fantastic,” *New Scientist*, 198, No. 2658, 39-41 (31 May 2008)
- Bokkon, I., “Phosphene phenomenon: A new concept,” *BioSystems*, 92, 168-174 (2008)

Related references

- Lewis-Williams, J. D., “Southern Africa's place in the archaeology of human understanding,” *South African Journal of Science*, Suid-Afrikaanse Tydskrif vir Wetenskap, 85, 47 (January 1989)
- Lewis-Williams, J. D., and T. A. Dowson, “The signs of all times. Entoptic phenomena in Upper Palaeolithic art,” *Current Anthropology*, 29, No. 2, 201-245 (April 1988)
- Hodgson, D., “Shamanism, phosphenes, and early art: an alternative synthesis,” *Current Anthropology*, 41, No. 5, 866-873 (December 2000)
- Kammer, T., K. Puls, M. Erb, and W. Grodd, “Transcranial magnetic stimulation in the visual system. II. Characterization of induced phosphenes and scotomas,” *Experimental Brain Research*, 160, 129-140 (2005)

7.8 Humming becomes a stroboscope

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References

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Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Rushton, W. A. H., “Effect of humming on vision,” *Nature*, 216, No. 5121, 1173-1175 (23 December 1967)
- Wells, A. M., and C. R. Evans, “Effect of humming on the visibility of a stabilized retinal image,” *Nature* 217, 1168-1169 (23 March 1968)
- Scott-Scott, J. L., “Effect of humming on vision,” *Nature*, 218, 306 (10 April 1968)
- Eastman, P. C., “Effect of humming on vision,” *Nature*, 222, 164 (12 April 1969)
- Williams, P. C., and T. P. Williams, “Effect of humming on watching television,” *Nature*, 239, 407 (13 October 1972)
- “Humming up an odd vizhual effect,” *New Scientist*, 63, 230 (1 August 1974) (vizhual is correct spelling)
- Werner, M. S., “Synchronous stabilization of visual perception by voice vibration,” *Journal of the Optical Society of America*, 64, 890 (June 1974)

- Mastebroek, H. A. K., and J. B. Van Der Kooi, “The effect of humming on vision,” *Physics Education*, 14, 253-254 (1979)
- Walker, J., “How to stop a spinning object by humming and perceive curious blue arcs around a light” in “The Amateur Scientist,” *Scientific American*, 250, No. 2, 136-145 (February 1984)
- Iverson, D., and P. Insley, “A humming strobe,” in “Doing Physics--- Physics Activities for Groups,” *Physics Teacher*, 22, 458 (October 1984)
- Gardner, M., “The Bronx cheer effect,” *Physics Teacher*, 39, 490 (November 2001)

Related reference

- Peli, E., and M. A. Garcia-Perez, “Motion perception during involuntary eye vibration,” *Experimental Brain Research*, 149, 431-438 (2003)

7.9 Keeping your eye on the baseball

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Hubbard, A. W., and C. N. Seng, “Visual movements of batters,” *Research Quarterly*, 25, 42-57 (1954)
- Johansson, G., “Visual motion perception,” *Scientific American*, 232, No. 6, 76-88 + 128 (June 1975)
- Regan, D., K. Beverley and M. Cynader, “The visual perception of motion in depth,” *Scientific American*, 241, No. 1, 136-151 + 162 (July 1979)
- Bahill, A. T., and T. LaRitz, “Why can't batters keep their eyes on the ball?” *American Scientist*, 72, 249-253 (May-June 1984); see also letters on page 433
- Allman, W. F., “The swing's the thing,” *Science* 85, 86-87 (April 1985)
- McLeod, P., “Visual reaction time and high-speed ball games,” *Perception*, 16, 49-59 (1987)

- Watts, R. G., and A. T. Bahill, *Keep Your eye on the Ball*, W. H. Freeman and Company, 1990, Chapters 7 and 8, ISBN 0-7167-2104-X
- Bahill, A. T., and W. J. Karnavas, “The perceptual illusion of baseball’s rising fastball and breaking curveball,” *Journal of Experimental Psychology: Human Perception and Performance*, 19, No. 1, 3-14 (February 1993)
- Masood, E., “Howzat! Why the best players don’t always watch the ball,” *New Scientist*, 168, 22 (25 November 2000)

Related reference

- Voisin, A., D. B. Elliott, and D. Regan, “Babe Ruth: with vision like that, how could he hit the ball?” *Optometry and Vision Science*, 74, No. 3, 144-146 (1997)
- Loomis, J. M., “Looking down is looking up,” *Nature*, 414, No. 6860, 155-156 (8 November 2001)

7.10 Impressionism

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Elliott, D. B., and A. Skaff, “Vision of the famous: the artist’s eye,” *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians*, 13, No. 1, 82-90 (January 1993)
 - Lane, R., N. Carey, R. Orrell, and R. T. Moxley III, (letter) “Claude Monet’s vision,” *Lancet*, 349, No. 9053, 734 (8 March 1997)
 - Dan, N. G., “Visual dysfunction in artists,” *Journal of Clinical Neuroscience*, 10, No. 2, 168-170 (2003)
 - Dahm, R., “Dying to see,” *Scientific American*, , 82-89 (October 2004), see page 88

Related references

- Pollard, Z. F., (letter) “El Greco’s vision,” *Survey of Ophthalmology*, 39, No. 2, 167 (September-October 1994)
- Itzhaki, J., “El Greco had style not astigmatism,” *New Scientist*, 147, No. 1996, 12 (23 September 1995)
- Hopkins, R., “Greco’s eyesight: interpreting pictures and the psychology of vision,” *Philosophical Quarterly*, 47, No. 189, 441-458 (October 1997)
- Lanthony, P., “Daltonism in painting,” *Color Research and Application*, Supplement Volume 26, S12-S16 (2001)

7.11 Pointillistic paintings

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<http://www.psych.ucalgary.ca/pace/va-lab/Brian/nature.htm> Discussion plus example

<http://blogs.princeton.edu/wri152-3/dlieber/archives/002188.html>

Discussion plus several examples

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Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Oster, G., “Optical art,” *Applied Optics*, 4, No. 11, 1359-1369 (November 1965), see page 1361
- Padgham, C. A., and J. E. Saunders, *The Perception of Light and Colour*, G. Bell & Sons, 1975, pages 132-133
- Fineman, M., *The Inquisitive Eye*, Oxford University Press, 1981, page 9
- Overheim, R. D., and D. L. Wagner, *Light and Color*, John Wiley, 1982, pages 45-50
- Williamson, S. J., and H. Z. Cummins, *Light and Color in Nature and Art*, John Wiley, 1983, pages 21-22, 30

- Falk, D., D. Brill, and D. Stork, *Seeing the Light: Optics in Nature, Photography, Color, Vision and Holography*, Harper & Row, 1986, pages 248, 261, 283
- Halliday, D., R. Resnick, and J. Walker, *Fundamentals of Physics*, John Wiley & Sons, 6th edition, 2001/2003, pages 890, 899-900; 7th edition, 2005, pages 100-1001
- “Optics unveils a masterpiece,” *Optics & Photonics News*, ??, 8 (September 2004)

7.12 Moiré patterns

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

<http://www.artlandia.com/products/SymmetryWorks/moire/moire2.html>

Moving example

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Firby, P. A., “Controlling interference in graphics,” *Mathematical Gazette*, ??, 118-124 (??)
- Minnaert, M., *Light and Colour in the Open Air*, Dover, 1954, pages 85-87
- Wood, E. A., “Moire patterns -- a demonstration,” *American Journal of Physics*, 30, 381-382 (1962)
- Oster, G., and Y. Nishijima, “Moire patterns,” *Scientific American*, 208, No. 5, 54-63 + 194 (May 1963)
- Stecher, M., “The moire phenomenon,” *American Journal of Physics*, 32, No. 4, 247-257 (April 1964)
- Stong, C. L., “Moire patterns provide both recreation and some analogues for solving problems” in “The Amateur Scientist,” *Scientific American*, 211, No. 5, 134-142 + 156 (November 1964)

- Oster, G., M. Wasserman, and C. Zwerling, “Theoretical interpretation of moiré patterns,” *Journal of the Optical Society of America*, 54, No. 2, 169-175 (February 1964)
- Nishijima, Y., and G. Oster, “Moire patterns: their application to refractive index and refractive index gradient measurements,” *Journal of Optical Society of America*, 54, No. 1, 1-5 (January 1964)
- Chiang, C., “Stereoscopic moiré patterns,” *Journal of the Optical Society of America*, 57, No. 9, 1088-1090 (September 1967)
- Mawdsley, J., “Demonstrating phase velocity and group velocity,” *American Journal of Physics*, 37, No. 8, 842-843 (1969)
- Martin, L. P., and F. D. Ju, “The moiré method for measuring large plane deformations: general theory and application to homogeneous deformation,” *Journal of Applied Mechanics*, 385-391 (September 1969)
- Stong, C. L., “Moire patterns draw contours, and a meter determines current in electronic circuits,” in “The Amateur Scientist,” *Scientific American*, 229, 120-125 + 132 (October 1973)
- Grafton, C. B., *Optical Designs in Motion with Moire Overlays*, Dover, 1976
- Piggins, D., “Moirés maintained internally by binocular vision,” *Perception*, 7, 679-681 (1978)
- Yokozeki, S., and S. Mihara, “Moire interferometry,” *Applied Optics*, 18, No. 8, 1275-1280 (15 April 1979)
- Heiniger, F., and T. Tschudi, “Moire depth contouring,” *Applied Optics*, 18, No. 10, 1577-1581 (15 May 1979)
- Marsch, J. S., “Contour plots using a moiré technique,” *American Journal of Physics*, 48, No. 1, 39-40 (January 1980)
- Watkins, J. F., “Kinetic art: producing unusual moiré effects by means of specially prepared drawings,” *Leonardo*, 15, No. 2, 133-136 (1982)
- Livnat, A., and O. Kafri, “Finite fringe shadow moiré slope mapping of diffusive objects,” *Applied Optics*, 22, No. 20, 3232-3235 (15 October 1983)
- Livnat, A., E. Keren, and O. Kafri, “Level based on moiré effect with ambient light,” *Applied Optics*, 23, 2412-2414 (1984)
- Dultz, W., “A cycloramic display using moiré enlargement of periodic picture arrays,” *Displays*, 5, No. 1, 37-39 (January 1984)
- Andonian, A. T., “Detection of stimulated back muscle contractions by moiré topography,” *Journal of Biomechanics*, 17, No. 9, 653-661 (1984)
- Gertzbein, S. D., K. H. Chan, M. Tile, J. Seligman, and A. Kapasouri, “Moire patterns: an accurate technique for determination of the locus of the centres of rotation,” *Journal of Biomechanics*, 18, No. 7, 501-509 (1985)

- Giger, H., “Moirés,” *Computers & Mathematics with Applications*, Part B, Nos. 1-2, 329-361 (1986)
- Isenberg, C., “Moire patterns,” *Physics Education*, 21, 348-349 (1986)
- Craine, H. R., “Three-dimensional moiré patterns,” in “How Things Work,” *Physics Teacher*, ??, 102-103 (February 1987)
- Meyer-Arendt, J. R., B. G. Smith, and R. J. Weekly, “More topgrams: a simple method for their evaluation,” *Applied Optics*, 26, No. 7, 1166-1167 (1 April 1987)
- Sandler, B., E. Keren, A. Livnat, and O. Kafri, “ Moire patterns of skewed radial gratings,” *Applied Optics*, 26, No. 5, 772-773 (1 March 1987)
- Bernero, B., “The moiré effect in physics teaching,” *Physics Teacher*, ??, 602-608 (October 1989)
- Szwaykowski, P., and K. Patorski, “More fringes by evolute gratings,” *Applied Optics*, 28, No. 21, 4679-4681 (1 November 1989)
- Spillmann, L., “The perception of movement and depth in moiré patterns,” *Perception*, 22, No. 3, 287-308 (1993)
- Hersch, R. D., and S. Chosson, “Band moiré images,” *ACM Transactions on Graphics*, 23, No. 3, 239-248 (August 2004)

Related references

- Mortimer, A. A., “Electronic dot generation,” *Physics and Technology*, 19, 188-195 (1988)
- Minnaert, M., *Light and Color in the Outdoors*, translated and revised by L. Seymour, Springer-Verlag, 1993, pages 104-109
- Brewer, A., and C. Forno, “Moire fringe analysis of cradled panel paintings,” *Studies in Conservation*, 42, No. 4, 211-230 (1997)

7.13 Op art

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

<http://www.ritsumeai.ac.jp/~akitaoka/index-e.html> Akiyoshi Kitaoka illusions (startling, especially “Rotating snakes”)

http://www.michaelbach.de/ot/mot_enigma/index.html

http://www.perceptionweb.com/perception/misc/p5542/p5542_1.jpg

http://thinksmart.typepad.com/good_morning_thinkers/images/moving_illusion.bmp Very good op art with illusory motion

<http://www.diycalculator.com/imgs/illusion-snakes-sm.jpg> Another good one

http://content.answers.com/main/content/wp/en-commons/thumb/9/9c/256px-Grid_illusion.svg.png As you move your eyes over the array, are the circles black or white or both?

<http://www.cns.nyu.edu/~alan/resources/illusions/snakeContrastFull.jpg> Move your eyes around the graphic.

<http://eluzions.com/Images/124x93/Illusions.gif>

<http://eluzions.com/Illusions/>

<http://www.digitalmediatree.com/tommoodys/op90s/getpic/1190/> Example

<http://www.f-lohmueller.de/pov/hypnoz2g.jpg> Use the buttons at the left to crawl around

<http://testwww.siggraph.org/education/materials/HyperVis/vision/ilus2.gif>

Subjective contour. A nonexistent square.

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Oster, G., "Optical art," *Applied Optics*, 4, No. 11, 1359-1369 (November 1965)
- Payne, W. H., and D. E. Anderson, "Border-Contrast: Corner Brightening Effects," *Vision Research*, 9, 1309-1313 (1969)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 214-218
- Lavin, E., and A. Costall, "Detection Thresholds of the Hermann Grid Illusion," *Vision Research*, 18, 1061-1062 (1978)
- McCarter, A., "Chromatic induction effects in the Hermann grid illusion," *Perception*, 8, 105-114 (1979)
- Levine, J., L. Spillmann, and E. Wolf, "Saturation Enhancement in Colored Hermann Grids Varying Only in Chroma," *Vision Research*, 20, 307-313 (1980)
- Oehler, R., and L. Spillmann, "Illusory Colour Changes in Hermann Grids Varying Only in Hue," *Vision Research*, 21, 527-541 (1981)

- Berbaum, K., and C. S. Chung, "Perceptive field sizes and a new version of the Hermann grid," *Perception*, 10, 85-89 (1981)
- Troscianko, T., "A Stereoscopic Presentation of the Hermann Grid," *Vision Research*, 22, 485-489 (1982)
- Parks, T. E., and W. Marks, "Illusory figures: individual differences in apparent depth and lightness," *Perception & Psychophysics*, 37, 529-532 (1985)
- Remole, A., A. S. Y. Ng, L. L. Bathe, P. D. Padfield, M. M. Spafford, and M. A. Szymkiw, "Flicker haloes observed with subjective borders," *Perception*, 14, 31-40 (1985)
- Ramachandran, V. S., "Apparent motion of subjective surfaces," *Perception*, 14, 127-134 (1985)
- Ramachandran, V. S., "Subjective contours capture stereopsis," *Nature*, 317, No. 6037, 527-530 (10 October 1985)
- Prazdny, K., "Capture of stereopsis by illusory contours," *Nature*, 324, 393 (November 1986); reply by V. S. Ramachandran, pages 393-394
- Deregowski, J. B., (letter) "Shape and contour---dots and dashes," *Perception*, 15, 217 (1986)
- Coren, S., C. Porac, and L. H. Theodor, "The effects of perceptual set on the shape and apparent depth of subjective contours," *Perception & Psychophysics*, 39, No. 5, 327-333 (1986)
- Vallortigara, G., "The hidden face of Kanizsa's triangle: apparent movement of subjective figures in three-dimensional space," *Perception*, 16, 449-452 (1987)
- Ramachandran, V. S., "Interaction between colour and motion in human vision," *Nature*, 328, No. 6131, 645-647 (13 August 1987)
- Ramachandran, V. S., "Interaction between colour and motion in human vision," *Nature*, 328, 645-647 (13 August 1987)
- Walker, J., "Colored segments of a grid can shed a diffuse glow like the light from a neon tube," in "The Amateur Scientist," *Scientific American*, 261, No. 5, 94-97 (November 1989)
- Mather, G., "The role of subjective contours in capture of stereopsis," *Vision Research*, 29, No. 1, 143-146 (1989)
- Earle, D. C., "Some observations on the perception of Marroquin patterns," *Perception*, 20, No. 16, 727-731 (1991)
- Winckelgren, I., "How the brain 'sees' borders where there are none," *Science*, 256, 1520-1521 (12 June 1992)

- Gregory, R. L., “A comment: Mackay rays shimmer due to accommodation changes,” *Proceedings of the Royal Society of London B*, 253, No. 1336, 123 (1993)
- Leviant, I., “Does ‘brain-power’ make *Enigma* spin?” *Proceedings of the Royal Society of London B*, 263, 997-1001 (1996)
- Hine, T., M. Cook, and G. T. Rogers, “The Ouchi illusion: an anomaly in the perception of rigid motion for limited spatial frequencies and angles,” *Perception & Psychophysics*, 59, No. 3, 448-455 (April 1997)
- Wilson, H. R., B. Krupa, and F. Wilkinson, “Dynamics of perceptual oscillations in form vision,” *Nature Neuroscience*, 3, No. 2, 170-176 (February 2000)
- Pinna, B., and G. J. Brelstaff, “A new visual illusion of relative motion,” *Vision Research*, 40, 2091-2096 (2000)
- Fermuller, C., R. Pless, and Y. Aloimonos, “The Ouchi illusion as an artifact of biased flow estimation,” *Vision Research*, 40, 77-96 (2000)
- Ninio, J., “Flashing lines,” in “Last But Not Least,” *Perception*, 30, No. 2, 253-257 (2001)
- Wade, N. J., “Movements in art: from Rosso to Riley,” *Perception*, 32, 1029-1036 (2003)
- Zanker, J. M., M. Doyle, and R. Walker, “Gaze stability of observers watching Op Art pictures,” *Perception*, 32, No. 9, 1037-1049 (2003)
- Zanker, J. M., and R. Walker, “A new look at op art: towards a simple explanation of illusory motion,” *Naturwissenschaften*, 91, 149-156 (2004)
- Zanker, J. M., “Looking at Op Art from a computational viewpoint,” *Spatial Vision*, 17, No. 1-2, 75-94 (2004)
- Murakami, I., A. Kitaoka, and H. Ashida, “A positive correlation between fixation instability and the strength of illusory motion in a static display,” *Vision Research*, 46, 2421-2431 (2006)
- Gori, S., K. Hamburger, and L. Spillmann, “Reversal of apparent rotation in the Enigma-figure with and without motion adaptation and the effect of T-junctions,” *Vision Research*, 46, 3267-3273 (2006)
- Kumar, T., and D. A. Glaser, “Illusory motion in Enigma: A psychophysical investigation,” *Proceedings of the National Academy of Sciences of the USA (PNAS)*, 103, No. 6, 1947-1952 (7 February 2006)
- Werner, J. S., and L. Spillma, “Illusory Color & the Brain,” *Scientific American*, 296, No. 3, 90-95 (March 2007)
- Hamburger, K., “Apparent rotation and jazzing in Leviant’s Enigma illusion,” *Perception*, 36, No. 6, 797-807 (2007)

- “See trickles in the circles? It’s ‘cause eyes are micro movers,” note, *New Scientist*, 199, No. 2675, 16 (27 September 2008)

7.14 Depth in oil paintings

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Williamson, S. J., and H. Z. Cummins, *Light and Color in Nature and Art*, John Wiley & Sons, 1983, pages 371-372
- Dalal, E. N., and K. M. Natale-Hoffman, “The effect of glass on color,” *Color Research and Application*, 24, No. 5, 369-376 (October 1999)
- Elias, M., L. Simonot, and M. Menu, “Bidirectional reflectance of a diffuse background covered by a partly absorbing layer,” *Optics Communications* 191, 1-7 (2001)
- Simonot, L., M. Elias, and E. Charron, “Special visual effect of art glazes explained by the radiative transfer equation,” *Applied Optics*, 43, No. 12, 2580-2587 (20 April 2004)
- Simonot, L., and M. Elias, “Color change due to varnish layer,” *Color Research and Application*, 29, No. 3, 196-204 (June 2004)
- Elias, M., and L. Simonot, “Bi-directional reflectance of a varnished painting. Part 1: Influence of the refractive indices without using the approximations of Saunderson correction---exact computation,” *Optics Communications*, 231, 17-24 (2004)
- Elias, M., L. Simonot, M. Thoury, and J. M. Frigerio, “Bi-directional reflectance of a varnished painting. Part 2: Comparison between the effects of the refractive indices of the surface states and of the absorption of the varnish---experiments and simulations,” *Optics Communications*, 231, 25-33 (2004)

Related reference

- Scuello, M., I. Abramov, J. Gordon, and S. Weintraub, “Museum lighting: optimizing the illuminant,” *Color Research and Application*, 29, No. 2, 121-127 (April 2004)

7.15 Reading in the dark

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Brindley, G. S., “The discrimination of afterimages,” *Journal of Physiology*, 147, No. 1, 194-203 (1959)
- Gregory, R. L., J. Wallace and F. W. Campbell, “Changes in the size and shape of visual after-images observed in complete darkness during changes of position in space,” *Quarterly Journal of Experimental Psychology*, 11, No. 1, 54-55 (1959)
- Brindley, G. S., “Afterimages,” *Scientific American*, 209, No. 4, 84-91 (October 1963)
- Miller, N. D., “Positive afterimage following brief high-intensity flashes,” *Journal of the Optical Society of America*, 56, No. 6, 802-806 (June 1966)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 243-245
- Gregory, R. L., *Concepts and Mechanisms of Perception*, Charles Scribner's Sons, 1974, Chapter 22
- MacLeod, D. I. A., and M. M. Hayhoe, “Rod origin of prolonged afterimages,” *Science*, 185, No. 4157, 1171-1172 (1974)
- Hayhoe, M. M., D. I. A. MacLeod and T. A. Bruch, “Rod-cone independence in dark adaptation,” *Vision Research*, 16, No. 6, 591-600 (1976)
- Gosline, C. J., D. I. A. MacLeod and W. A. H. Rushton, “The dark adaptation curve of rods measured by their afterimage,” *Journal of Physiology*, 259, No. 2, 491-499 (1976)

- Sakitt, B., “Psychophysical correlates of photoreceptor activity,” *Vision Research*, 16, No. 2, 129-140 (1976)
- Friedman, H., and A. L. Marchese, “Positive after-image, PAI: early erasure by saccadic eye movement or Jendrassik manoeuvre,” *Experientia*, 34, 71-73 (1978)
- Adelson, E. H., “Visual persistence without the rods,” *Perception & Psychophysics*, 26, No. 3, 245-246 (1979)
- Kriegman, D. H., and I. Biederman, “How many letters in Bidwell's ghost? An investigation of the upper limits of full report from a brief visual stimulus,” *Perception & Psychophysics*, 28, No. 1, 82-84 (1980)
- Geisler, W. S., “Increment threshold and detection latency in the rod and cone systems,” *Vision Research*, 20, No. 11, 981-994 (1980)
- Power, R. P., S. Hausfeld, and A. Gorta, *Workshops in Perception*, Routledge & Kegan Paul, 1981, Chapter 21
- Adelson, E. H., “The delayed rod afterimage,” *Vision Research*, 22, 1313-1328 (1982)
- Power, R. P., “Apparent movement induced by afterimages,” *Perception*, 12, 463-467 (1983)
- Walker, J., “Bidwell's ghost and other phenomena associated with the positive afterimage” in “The Amateur Scientist,” *Scientific American*, 252, No. 2, 122-128 (February 1985)
- Walker, J., “The Amateur Scientist,” *Scientific American*, 252, 122 (March 1985); see page 126
- Bross, M., “Emmert’s law in the dark: active and passive proprioceptive effects on positive visual afterimages,” *Perception*, 29, No. 11, 1385-1391 (2000)

7.16 Trailing ghost light

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 243-245
- Walker, J., “Bidwell's ghost and other phenomena associated with the positive afterimage” in “The Amateur Scientist,” *Scientific American*, 252, No. 2, 122-128 (February 1985)

7.17 Reflecting eyes

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Nassau, K., *The Physics and Chemistry of Color: The Fifteen Causes of Color*, Wiley, ??, pages 269 and Color Plate 24
- Weale, R. A., “The spectral reflectivity of the cat's tapetum measured in situ,” *Journal of Physiology*, 119, 30-42 (1953)
- Pirie, A., “The biochemistry of the eye,” *Nature*, 186, No. 4722, 352-354 (30 April 1960)
- Land, M. F., “Image formation by a concave reflector in the eye of the scallop, *Pecten Maximus*,” *Journal of Physiology*, 179, 138-153 (1965)
- Land, M. F., “A multilayer interference reflector in the eye of the scallop, *Pecten Maximus*,” *Journal of Experimental Biology*, 45, 433-447 (1966)
- Huxley, A. F., “A theoretical treatment of the reflexion of light by multilayer structures,” *Journal of Experimental Biology*, 48, No. 2, 227-245 (1968)
- Denton, E. J., “On the Organization of Reflecting Surfaces in Some Marine Animals,” *Philosophical Transactions of the Royal Society of London B*, 258, 285 (1970)
- Denton, E., “Reflectors in fishes,” *Scientific American*, 224, No. 1, 64-72 (January 1971)

- Coles, J. A., “Some reflective properties of the tapetum lucidum of the cat's eye,” *Journal of Physiology*, 212, 393-409 (1971)
- Land, M. F., “The physics and biology of animal reflectors,” *Progress in Biophysics and Molecular Biology*, 24, 75-106 (1972)
- Land, M. F., “Animal eyes with mirror optics,” *Scientific American*, 239, No. 6, 126-133 (December 1978)
- Ribi, W. A., “The phenomenon of eye glow,” *Endeavour, New Series*, 5, 2-7 (1980)
- Williamson, S. J., and H. Z. Cummins, *Light and Color in Nature and Art*, Wiley, 1983, pages 320, 322
- Grant, R. M., “The red-eye effect,” *Physics Teacher*, 23, 514-515 (1985)
- Van Norren, D., and L. F. Tiemeijer, “Spectral reflectance of the human eye,” *Vision Research*, 26, 313-320 (1986)
- Land, M. F., “The optics of animal eyes,” *Contemporary Physics*, 29, No. 5, 435-455 (1988)
- Land, M. F., “Eyes with mirror optics,” *Journal of Optics A: Pure and Applied Optics*, 2, R44-R50 (2000)
- Parker, A. R., “515 million years of structural colour,” *Journal of Optics A: Pure and Applied Optics*, R15-R28 (2000)
- DeWeerd, A. J., (letters) “Dog eyes in flash photos,” *Physics Teacher*, 42, 196 (April 2004)
- McNeill, J., (letter) “Reflective dog eyes,” *Physics Teacher*, 43, 405-406 (October 2005)
- Parker, A. R., “A geological history of reflecting optics,” *Journal of the Royal Society Interface*, 2, 1-17 (2005)
- Colicchia, G., C. Waltner, M. Hopf, and H. Wiesner, “The scallop's eye --- a concave mirror in the context of biology,” *Physics Education*, 44, No. 2, 175-179 (March 2009)

Related reference

- Warrant, E. J., “Seeing better at night: life style, eye design and the strategy of spatial and temporal summation,” *Vision Research*, 39, 1611-1630 (1999)

7.18 Underwater vision of humans, penguins, and crocodiles

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Baddeley, A. D., “Diver performance,” *Underwater Science. An Introduction to Experiments by Divers*, J. D. Woods and J. N. Lythgoe, Oxford University Press, 1971, pages 47-50, 65-66
- Howland, H. C., and J. G. Sivak, “Penguin vision in air and water,” *Vision Research*, 24, No. 12, 1905-1909 (1984)
- Martin, G., “Through a penguin's eye,” *New Scientist*, 105, No. 1447, 29-31 (14 March 1985)
- Fleishman, L. J., H. C. Howland, M. J. Howland, A. S. Rand, and M. L. Davenport, “Crocodiles don't focus underwater,” *Journal of Comparative Physiology A*, 163, 441-443 (1988)
- White, J. D., and L. R. White, “Answer to question #33 [“Underwater vision of dolphins and terns,” Clifford E. Swartz, *Am. J. Phys.* 64(1), 13 (1996)],” *American Journal of Physics*, 64, No. 11, 1353-1355 (November 1996)
- Steele, A. L., “Vision underwater,” *Physics Education*, 32, No. 6, 387-392 (November 1997)
- Martin, G. R., “Eye structure and foraging in King Penguins *Aptenodytes patagonicus*,” *Ibis*, 141, No. 3, 444-450 (July 1999)
- Gislen, A., M. Dacke, R. H. H. Kroger, M. Abrahamsson, D.-E. Nilsson, and E. J. Warrant, “Superior underwater vision in a human population of sea gypsies,” *Current Biology*, 13, 833-836 (13 May 2003)
- Gislen, A., and L. Gislen, “On the optical theory of underwater vision in humans,” *Journal of the Optical Society of America A*, 21, No. 11, 2061-2064 (November 2004)

7.19 Underwater vision of “four-eyed fish”

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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<http://www.elacuarista.com/secciones/biologia7.htm>

Photo of the fish that can see in both air and water.

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Borwain, B., and M. J. Hollenberg, “The photoreceptors of the ‘four-eyed’ fish, *Anableps anableps* L,” *Journal of Morphology*, 140, 405-442 (??)
- Warner, C. P., “Nature's alert eyes,” *National Geographic*, 115, No. 4, 558 (April 1959), see page 568
- Schwassmann, H. O., “Experimental analysis of the visual system of the four-eyed fish *Anableps microlepis*,” *Vision Research*, 5, 269-281 (1965)
- Baddeley, A. D., “Diver performance,” in *Underwater Science: An Introduction to Experiments by Divers*, J. D. Woods and J. N. Lythgoe, editors, Oxford University Press, 1971, pages 47-50 + 65-66
- Sivak, J. G., “Optics of the eye of the ‘four-eyed fish’ (*Anableps anableps*),” *Vision Research*, 16, 531-534 (1976)
- Falk, D. S., D. R. Brill, and D. G. Stork, *Seeing the Light. Optics in Nature, Photography, Color, Vision, and Holography*, Harper & Row, 1986, page 147
- White, J. D., and L. R. White, “Answer to question #33 [“Underwater vision of dolphins and terns,” Clifford E. Swartz, *Am. J. Phys.* 64(1), 13 (1996)],” *American Journal of Physics*, 64, No. 11, 1353-1355 (November 1996)
- Meyer, D. L., C. R. Malz, and A. G. Jadhao, “Nervus terminalis projection to the retina in the ‘four-eyed’ fish, *Anableps anableps*,” *Neuroscience Letters*, 213, 87-90 (1996)
- Saidel, W. M., and R. S. Fabiane, “Optomotor response of *Anableps anableps* depends on the field of view,” *Vision Research*, 38, 2001-2006 (1998)

- Albeni, B. C., and J. H. Powell, “The differential optomotor response of the four-eyed fish *Anableps anableps*,” *Perception*, 27, No. 12, 1475-1483 (1998)
- Swamynathan, S. K., M. A. Crawford, W. G. Robison, Jr., J. Kanungo, and J. Piatigorsky, “Adaptive differences in the structure and macromolecular compositions of the air and water corneas of the ‘four-eyed’ fish (*Aanableps anableps*),” *FASEB Journal*, 17, 1996-2005 (2003)
- Swamynathan, S. K., M. A Crawford, W. G. Robinson Jr., J. Kanungo, and J. Piatigorsky, “Adaptive differences in the structure and macromolecular compositions of the air and water corneas of the ‘four-eyed’ fish (*Anableps anableps*),” *FASEB Journal*, 17, 1996-2005 (November 2003)
- Kanungo, J., S. K. Swamynathan, and J. Piatigorsky, “Abundant corneal gelsolin in Zebrafish and the ‘four-eyed’ fish, *Anableps anableps*: possible analogy with multifunctional lens crystallins,” *Experimental Eye Research*, 79, 949-956 (2004)
- Kanungo, J., S. K. Swamynathan, and J. Piatigorsky, “Abundant corneal gelsolin in Zebrafish and the ‘four-eyed’ fish, *Anableps anableps*: possible analogy with multifunctional lens crystallins,” *Experimental Eye Research*, 79, 949-956 (2004)

7.20 Cheshire cat effect

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Grindley, G. C., and V. Townsend, “Binocular masking induced by a moving object,” *Quarterly Journal of Experimental Psychology*, 17, 97-107 (1965)
- Blake, R., and J. Camisa, “Is binocular vision always monocular?” *Science*, 200, 1497-1499 (30 June 1978)

- Duensing, S., and B. Miller, “The Cheshire cat effect,” *Perception*, 8, 269-273 (1979)
- Walker, J., “Concerning disappearances, including the cheshire cat's odd vanishing act” in “The Amateur Scientist,” *Scientific American*, 256, No. 5, 122-126 (May 1987)
- Ooi, T. L., and Z. J. He, “Binocular rivalry and visual awareness: the role of attention,” *Perception*, 28, No. 5, 551-574 (1999)

Related references

- Krol, J. D., and W. A. van de Grind, “The double-nail illusion: experiments on binocular vision with nails, needles, and pins,” *Perception*, 9, 651-669 (1980)
- Lee, S.-H., “Binocular battles on multiple fronts,” *Trends in Cognitive Sciences*, 8, No. 4, 148-151 (April 2004)

7.21 Rhino-optical effect

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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http://virtuallibrary.stao.ca/sci-tie-data/lessons/1300_1399/1395.htm Page from the Science Teachers' Association of Ontario.

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Wade, N. J., *Brewster and Wheatstone on Vision*, Academic Press, 1983, pages 93 ff
- Mapp, A. P., and H. Ono, “The rhino-optical phenomenon: ocular parallax and the visible field beyond the nose,” *Vision Research*, 26, 1163-1165 (1986)
- Walker, J., “Concerning disappearances, including the Cheshire cat's odd vanishing act” in “The Amateur Scientist,” *Scientific American*, 256, No. 5, 122-126 (May 1987)

- Bingham, G. P., “The implications of ocular occlusion,” *Ecological Psychology*, 5, No. 3, 235-253 (1993)
- Bingham, G. P., “Optical flow from eye movement with head immobilized: ‘ocular occlusion’ beyond the nose,” *Vision Research*, 33, Nos. 5-6, 777-789 (March-April 1993)

Related reference

- Hayhoe, M. M., and D. R. Williams, “Disappearance of afterimages at ‘impossible’ locations in space,” *Perception*, 13, 455-459 (1984)

7.22 Flying clouds and Blue Meanies

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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http://www.wilsonsalmanc.com/images1/blue_meanies.jpg The blue meanies, not the illusion

References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

Ericksson, E. S., “Movement parallax during locomotion,” *Perception & Psychophysics*, 16, 197 (1974)

- Shipley, T., “Flying clouds: an illusion of visual capture and distance reversal,” *Vision Research*, 16, 1522-1524 (1976)

7.23 Pulfrich illusion

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Lythgoe, R. J., "Some observations on the rotating pendulum," *Nature*, 141, 474 (1938)
- Ives, R. L., "The sequence illusion," *Journal of the Franklin Institute*, 230, 755 (1940)
- Lit, A., "The magnitude of the Pulfrich stereophenomenon as a function of binocular differences of intensity at various levels of illumination," *American Journal of Psychology*, 62, 159-181 (1949)
- Rock, M. L., and B. H. Fox, "Two aspects of the Pulfrich phenomenon," *American Journal of Psychology*, 62, 279-284 (1949)
- Lit, A., and A. Hyman, "The magnitude of the Pulfrich stereophenomenon as a function of distance of observation," *American Journal of Optometry and Archives of American Academy of Optometry*, Monograph no. 122, 1-17 (November 1951)
- Katz, M. S., and I. Schwartz, "New observation of the Pulfrich effect," *Journal of the Optical Society of America*, 45, No. 7, 523-524 (July 1955)
- Dodwell, P., G. Harker and I. Behar, "Pulfrich effect with minimal differential adaptation of the eyes," *Vision Research*, 8, 1431-1443 (1968)
- Lit, A., "Illumination effects on depth discrimination," *Optometric Weekly*, 59, 42-55 (14 November 1968)
- Prestrude, A. M., and H. D. Baker, "New method of measuring visual-perceptual latency differences," *Perception and Psychophysics*, 4, 152-154 (1968)
- Julesz, B., and B. White, "Short term visual memory and the Pulfrich phenomenon," *Nature*, 222, No. 5194, 639-641 (17 May 1969)
- Wilson, J.A., and S. M. Anstis, "Visual delay as a function of luminance," *American Journal of Psychology*, 83, 350-358 (1969)
- Enright, J. T., "Distortions of apparent velocity: a new optical illusion," *Science*, 168, 464-467 (1970)
- Hansteen, R. W., "Visual latency as a function of stimulus onset, offset, and background luminance," *Journal of the Optical Society of America*, 61, No. 9, 1190-1195 (September 1971)
- Prestrude, A. M., "Prestrude, A. M., "Visual latencies at photopic levels of retinal illuminance," *Vision Research*, 11, 351-361 (1971)

- Prestrude, A. M., and H. D. Baker, "Light adaptation and visual latency," *Vision Research*, 11, 363-369 (1971)
- Rogers, B. J., and S. M. Anstis, "Intensity versus adaptation and the Pulfrich stereophenomenon," *Vision Research*, 12, 909-928 (1972)
- Levick, W. R., B. G. Cleland, and J. S. Coombs, "On the apparent orbit of the Pulfrich pendulum," *Vision Research*, 12, No. 8, 1381-1388 (1972)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 188-194
- Mansfield, R. J. W., "Latency functions in human vision," *Vision Research*, 13, 2219-2234 (1973)
- Harker, G. S., "Assessment of binocular vision utilizing Pulfrich and Venetian blind effects," *American Journal of Optometry and Archives of American Academy of Optometry*, 50, 435-445 (June 1973)
- Morgan, M. J., and P. Thompson, "Apparent motion and the Pulfrich effect," *Perception*, 4, 3-18 (1974)
- Rogers, B. J., J. J. Steinbach and H. Ono, "Eye movements and the Pulfrich phenomenon," *Vision Research*, 14, 181-185 (1974)
- Ross, J., and J. H. Hogben, "The Pulfrich effect and short-term memory in stereopsis," *Vision Research*, 15, 1289-1290 (1975)
- Vicars, W. M., and A. Lit, "Reaction time to incremental and decremental target luminance changes at various photopic background levels," *Vision Research*, 15, 261-265 (1975)
- Brauner, J. D., and A. Lit, "The Pulfrich effect, simple reaction time, and intensity discrimination," *American Journal of Psychology*, 89, No. 1, 105-114 (March 1976)
- Morgan, M. J., "Pulfrich effect and the filling in of apparent motion," *Perception*, 5, 187-195 (1976)
- Mansfield, R. J. W., and J. G. Daugman, "Retinal mechanisms of visual latency," *Vision Research*, 18, 1247-1260 (1978)
- Walker, J., "Visual illusions that can be achieved by putting a dark filter over one eye" in "The Amateur Scientist," *Scientific American*, 238, 142-153 + ?? (March 1978)
- Walker, J., "Visual illusions in random-dot patterns and television 'snow'" in "The Amateur Scientist," *Scientific American*, 242, 172-176 + ?? (April 1980)
- Walker, J., "Illusions in the snow: more fun with random dots on the television screen" in "The Amateur Scientist," *Scientific American*, 242, 176-184 + ?? (May 1980)

- Walker, J., “The Amateur Scientist,” *Scientific American*, 245, 176-187 (July 1981); see pages 186-187
- Fineman, M., *The Inquisitive Eye*, Oxford University Press, 1981, pages 95-101
- Power, R. P., S. Hausfeld, and A. Gorta, *Workshops in Perception*, Routledge & Kegan Paul, 1981, Chapter 2
- Landrigan, D. T., and I. A. Bader, “The Pulfrich effect: filtering portions of both eyes,” *Journal of Psychology*, 109, 165-172 (1981)
- Williams, J. M., and A. Lit, “Luminance-dependent visual latency for the Hess effect, the Pulfrich effect, and simple reaction time,” *Vision Research*, 23, No. 2, 171-179 (1983)
- Ono, H., and M. J. Steinbach, “The Pulfrich phenomenon with eye movement,” *Vision Research*, 23, No. 12, 1735-1737 (1983)
- Harris, J. M., “A new candidate for 3-D display,” *Photonics Spectra*, 17, No. 6, 45-51 (June 1983)
- Gregory, R. L., “A self-maintained Pulfrich pendulum (apparatus note),” *Perception*, 13, 633-634 (1984)
- Landrigan, D. T., “Measurements of the Pulfrich effect over days of exposure,” *Journal of Psychology*, 117, 125-133 (1984)
- Enright, J. T., “On Pulfrich-illusion eye movements and accommodation vergence during visual pursuit,” *Vision Research*, 25, No. 11, 1613-1622 (1985)
- Nickalls, R. W. D., “The rotating Pulfrich effect, and a new method of determining visual latency differences,” *Vision Research*, 26, No. 2, 367-372 (1986)
- Wilson, J. A., and J. O. Robinson, “The impossibly twisted Pulfrich pendulum,” *Perception*, 15, 503-504 (1986)
- Carney, T., M. A. Paradiso, and R. D. Freeman, “A physiological correlate of the Pulfrich effect in cortical neurons of the cat,” *Vision Research*, 29, No. 2, 155-169 (1989)
- Emerson, P. L., and B. J. Pesta, “A generalized visual latency explanation of the Pulfrich phenomenon,” *Perception & Psychophysics*, 51, No. 4, 319-327 (1992)
- Nickalls, R. W. D., “The influence of target angular velocity on visual latency difference determined using the rotating Pulfrich effect,” *Vision Research*, 36, No. 18, 2865-2872 (1996)
- Diaper, C. J. M., “Pulfrich revisited,” *Survey of Ophthalmology*, 41, No. 6, 493-499 (May-June 1997)

- Wardle, D. A., “The time delay in human vision,” *Physics Teacher*, 36, 442-444 (October 1998)
- Diaper, C. J. M., F. R. C. Ophth, G. Heron, and G. N. Dutton, (letter) “The Pulfrich phenomenon,” *Ophthalmology*, 106, No. 9, 1645-1646 (September 1999)
- Lages, M., P. Mamassian, E. W. Graf, “Spatial and temporal tuning of motion in depth,” *Vision Research*, 43, 2861-2873 (2003)
- Gregory, R., and P. Heard, “Public perceptions,” *Perception*, 32, 253-254 (2003)
- Lages, M., P. Mamassian, and E. W. Graf, “Spatial and temporal tuning of motion in depth,” *Vision Research*, 43, 2861-2873 (2003)
- Gregory, R., and P. Heard, “Public perceptions,” *Perception*, 32, 253-254 (2003)
- Kham, K., “An opaque surface influences the depth from the Pulfrich phenomenon,” *Perception*, 33, No. 10, 1201-1213 (2004)
- Heron, G., “Pulfrich’s phenomenon in a case of optic nerve hypoplasia,” *Ophthalmic and Physiological Optics*, 28, No. 1, 100 (2008)

7.24 Streetlight delay sequence

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Ives, R. L., “The sequence illusion,” *Journal of the Franklin Institute*, 230, 755-763 (1940)

7.25 Mach bands

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

<http://www.psych.ndsu.nodak.edu/mccourt/Projects/Brightness/Mach/Mach%20bands.htm> Photo showing the effect

References

- Dots • through ••• indicate level of difficulty
 Journal reference style: author, journal, volume, pages (date)
 Book reference style: author, title, publisher, date, pages
- Minnaert, M., *Light and Colour in the Open Air*, Dover, 1954, pages 129-132
 - Ratliff, F., *Mach Bands: Quantitative Studies on Neural Networks in the Retina*, Holden-Day, Inc., San Francisco, 1965, Chapter 2
 - Welford, W. T., "The visual Mach effect," *Physics Education*, 3, 83-84 (1968)
 - Bekesy, G. von, "Mach- and Herring-type lateral inhibition in Vision," *Vision Research*, 8, No. 12, 1483-1499 (1968)
 - Jacobson, J. Z., and G. E. MacKinnon, "Coloured Mach bands," *Canadian Journal of Psychology*, 23, 56-65 (1969)
 - Green, D. G., and M. B. Fast, "On the appearance of Mach bands in gradients of varying color," *Vision Research*, 11, 1147-1155 (1971)
 - Ratliff, F., "Contour and contrast," *Scientific American*, 226, No. 6, 90-101 (June 1972)
 - Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 198-205
 - Anstis, S. M., "A simple method of projecting Mach bands, color mixtures, and variable contrast sinusoidal gratings," *Behavior Research Methods & Instrumentation*, 7, No. 3, 283-287 (1975)
 - Crovitz, H. F., "Perceived length and the Craik-O'Brien illusion," *Vision Research*, 16, 435 (1976)
 - Lane, E. J., A. V. Proto and T. W. Phillips, "Mach bands and density perception," *Radiology*, 121, 9-17 (October 1976)
 - Brink, G. Van Den and C. J. Keemink, "Luminance gradients and edge effects," *Vision Research*, 16, 155-159 (1976)

- Dooley, R. P., and M. I. Greenfield, “Measurements of edge-induced visual contrast and a spatial-frequency interaction of the Cornsweet illusion,” *Journal of the Optical Society of America*, 67, No. 6, 761-765 (June 1977)
- Matin, L., and A. S. Kornheiser, “Reversal of the edge effect for the increment threshold with a small background,” *Vision Research*, 17, No. 6, 742-747 (1977)
- Anstis, S. M., I. P. Howard, and B. Rogers, “A Craik-O'Brien-Cornsweet illusion For visual depth,” *Vision Research*, 18, 213-217 (1978)
- Pease, P. L., “On color Mach bands,” *Vision Research*, 18, 751-755 (1978)
- Ratliff, F., N. Milkman and T. Kaufman, “Mach bands are attenuated by adjacent bars or lines,” *Journal of the Optical Society of America*, 69, No. 10, 1444 (1979)
- Frisby, J., *Seeing: Illusion, Brain and Mind*, Oxford University Press, 1980, pages 137-139
- Fineman, M., *The Inquisitive Eye*, Oxford University Press, 1981, pages 137-139
- Ross, J., J. J. Holt and J. R. Johnstone, “High frequency limitations on Mach bands,” *Vision Research*, 21, 1165-1167 (1981)
- Sakata, H., “Mechanism of Craik-O'Brien effect,” *Vision Research*, 21, 693-699 (1981)
- Ratliff, F., N. Milkman and N. Rennert, “Attenuation of Mach bands by adjacent stimuli,” *Proceedings of the National Academy of Sciences of the United States of America—Biological Sciences*, 80, 4554-458 (1983)
- Emerson, P. L., “Cornsweet contrast, shadow, and lightness: a critique of interpretations by Redding and Lester,” *Preception & Psychophysics*, 33, No. 5, 494-498 (1983)
- Ware, C. and B. W. Cowan, “The chromatic Cornsweet effect,” *Vision Research*, 23, No. 10, 1075-1077 (1983)
- Ratliff, F., “Why Mach bands are not seen at the edges of a step,” *Vision Research*, 24, No. 2, 163-165 (1984)
- Monrrone, M. C., J. Ross, D. C. Burr and R. Owens, “Mach bands are phase dependent,” *Nature*, 324, 250-253 (20 November 1986)
- Falk, D. S., D. R. Brill, and D. G. Stork, *Seeing the Light. Optics in Nature, Photography, Color, Vision, and Holography*, Harper & Row, 1986, page 188
- Lock, J. A., “Fresnel diffraction effects in misfocused vision,” *American Journal of Physics*, 55, No. 3, 265-269 (March 1987)

- Ross, J., M. C. Morrone, and D. C. Burr, “The conditions under which Mach bands are visible,” *Vision Research*, 29, 699-715 (1989)
- Minnaert, M., *Light and Color in the Outdoors*, translated and revised by L. Seymour, Springer-Verlag, 1993, pages 152-154
- Purves, D., A. Shimpi, and R. B. Lotto, “An empirical explanation of the Cornsweet effect,” *Journal of Neuroscience*, 19, No. 19, 8542-8551 (1 October 1999)

7.26 An upside down world

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Witkin, H. A., “The perception of the upright,” *Scientific American*, 200, No. 2, 50-56 (February 1959)
- Rock, I., *The Nature of Perceptual Adaptation*, Basic Books, 1966, pages ??
- Welch, R. B., M. H. Widawski, J. Harrington and D. H. Warren, “An examination of the relationship between visual capture and prism adaptation,” *Perception & Psychophysics*, 25, No. 2, 126-132 (1979)
- Kaufman, L., *Perception: The World Transformed*, Oxford University Press, 1979, pages 373-378
- Frisby, J., *Seeing: Illusion, Brain and Mind*, Oxford University Press, 1980, page 11
- Rock, I., *Perception*, Scientific American Library, 1984, Chapter 8
- Howard, I. P., G. Hu, Rebecca Saxe, and J. E. Zacher, “Visual orientation in a mirror world tilted 90°,” *Perception*, 34, 7-15 (2005)

7.27 Inverted shadows, and the blister effect

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Hirsh Jr., F. R., and E. M. Thorndike, "On the pinhead shadow inversion phenomenon," *American Journal of Physics*, 12, 164-165 (1944)
- du Mas, F. M., "A new visual illusion," *American Journal of Psychology*, 66, 142-143 (1953)
- Trotter, J. R., "The geometrical optics of the blister effect," *Vision Research*, 6, 587-596 (1966)
- Barnes, G., "Inversion of an image on the retina," *Physics Teacher*, 19, 499 (October 1981)
- Ficken, G. W., "Behind the eye," *Physics Teacher*, 20, 72 (February 1982)
- Doyle, H. A., "Demonstrations of inverted images on the retina," *American Journal of Physics*, 60, 474 (1992)
- Mamola, K. C., "Inversion of shadows on the retina," *Physics Teacher*, 21, No. 5, 332-333 (May 1983)
- Lock, J. A., "Ray theory analysis of the shadow blister effect," *Applied Optics*, 38, No. 9, 1573-1578 (March 1998), contained on Classic Reprints on CD-ROM Vol. 1, *On Minnaert's Shoulders: Twenty Years of the "Light and Color" Conferences*, C. L. Adler editor, 1999, Optical Society of America, ISBN 1-55752-621-4; <http://www.osa.org>
- Layton, B., "Inverted images and noninverted shadows," *Physics Teacher*, 39, 530-532 (December 2001)
- Dick, S. J., "The transit of Venus," *Scientific American*, 290, No. 5, 98-105 (May 2004), see caption on pages 103 and text on pages 104
- Sheehan, W., "The transit of Venus," *Sky & Telescope*, 107, No. 5, 32-37 (May 2004)
- Westfall, J., "A most agreeable spectacle. Last June millions of people watched Venus cross the face of the Sun," *Sky & Telescope*, 108, No. 5, 78-83 (November 2004)

7.28 Peculiar reflection from a Christmas tree ball

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

●●● Berry, M. V., “Reflections on a Christmas-tree bauble,” *Physics Education*, 7, 1-5 (1972) 1972

●●● van Beveren, E., F. Kleefeld, and G. Rupp, “Images in Christmas baubles,” *European Journal of Physics*, 27, 337-346 (2006)

7.29 Rotated random dot patterns

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

• MacKay, D. M., “Central adaptation in mechanisms of form vision,” *Nature*, 203, No. 4948, 993-994 (29 August 1964)

• MacKay, D. M., “Visual noise as a tool of research,” *Journal of General Psychology*, 72, 181-197 (1965)

●● Glass, L., “Moire effect from random dots,” *Nature*, 223, 578-580 (9 August 1969)

●● Glass, L., and R. Perez, “Perception of random dot interference patterns,” *Nature*, 246, No. 5432, 360-362 (7 December 1973)

●● Glass, L., and E. Switkes, “Pattern recognition in humans: correlations which cannot be perceived,” *Perception*, 5, 67-72 (1976)

- Bell, H. H., and J. S. Lappin, “The detection of rotation in random-dot patterns,” *Perception & Psychophysics*, 26, No. 5, 415-417 (1979)
- Glass, L., “Physiological mechanisms for the perception of random dot moiré patterns” in *Pattern Formation by Dynamic Systems and Pattern Recognition*, H. Haken, editor, Springer-Verlag, 1979, pages 127-134
- Walker, J., “Visual illusions in random-dot patterns and television 'snow'” in “The Amateur Scientist,” *Scientific American*, 242, 172-178 (April 1980)
- Walker, J., “More about random-dot displays, plus computer programs to generate them” in “The Amateur Scientist,” *Scientific American*, 243, 198-210 (November 1980)
- Pickover, C. A., “Use of random-dot displays in the study of biomolecular conformation,” *Journal of Molecular Graphics*, 2, No. 2, 35-38 (June, 1984)
- Prazdny, K., “On the perception of Glass patterns,” *Perception*, 13, 469-478 (1984)
- Earle, D. C., “Perception of Glass pattern structure with stereopsis,” *Perception*, 14, 545-552 (1985)
- Earle, D. C., “Surface contours, Glass patterns, and a slant illusion,” *Perception*, 15, 537-540 (1986)
- Giger, H., “Moirés,” *Computers & Mathematics with Applications*, Part B, Nos. 1-2, 329-361 (1986)
- Maloney, R. K., G. J. Mitchison, and H. B. Barlow, “Limit to the detection of Glass patterns in the presence of noise,” *Journal of the Optical Society of America A*, 4, No. 12, 2336-2341 (December 1987)
- Wilson, H. R., F. Wilkinson, and W. Asaad, “Concentric orientation summation in human form vision,” *Vision Research*, 37, No. 17, 2325-2330 (1997)
- Glass, L., “Looking at dots,” *Mathematical Intelligencer*, 24, No. 4, 37-43 (2002)
- Dakin, S. C., and P. J. Bex, “Summation of concentric orientation structure: seeing the Glass or the window?” *Vision Research*, 42, 2013-2020 (2002)
- Kurki, I., P. Laurinen, T. Peromaa, and J. Saainen, “Spatial integration in Glass patterns,” *Perception*, 32, 1211-1220 (2003)
- Wilson, J. A., E. Switkes, and R. L. De Valois, “Glass pattern studies of local and global processing of contrast variations,” *Vision Research*, 44, 2629-2641 (2004)
- Lewis, T. L., D. Ellemberg, D. Maurer, M. Dirks, F. Wilkinson, and H. R. Wilson, “A window on the normal development of sensitivity to global form in Glass patterns,” *Perception*, 33, 409-418 (2004)

- Khuu, S. K., and A. Hayes, “Glass-pattern detection is tuned for stereodepth,” *Vision Research*, 45, 2461-2469 (2005)
- Ohla, K., N. A. Busch, M. A. Dahlem, and C. S. Herrmann, “Circles are different: The perception of Glass patterns modulates early event-related potentials,” *Vision Research*, 45, 2668-2676 (2005)
- Chung, C. S., K. Kham, and C. Oh, “Bistable Glass-pattern motion reveals two different processes,” *Vision Research*, 45, 2752-2758 (2005)
- Ross, J. and J. E. Dickinson, “Effects of adaptation to Glass pattern structure and to path of optic flow,” *Vision Research*, 47, 2150-2155 (2007)

Related references

- Wilson, H. R., G. Loffler, F. Wilkinson, and W. A. Thistlethwaite, “An inverse oblique effect in human vision,” *Vision Research*, 41, 1749-1753 (2001)
- Clifford, C. W. G., and E. Weston, “Aftereffect of adaptation to Glass patterns,” *Vision Research*, 45, 1355-1363 (2005)

7.30 Patterns in television “snow”

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

- Dots • through ••• indicate level of difficulty
 Journal reference style: author, journal, volume, pages (date)
 Book reference style: author, title, publisher, date, pages
- MacKay, D. M., “Moving visual images produced by regular stationary patterns,” *Nature*, 180, No. 4591, 849-850 (26 October 1957)
 - MacKay, D. M., “Some further visual phenomena associated with regular patterned stimulation,” *Nature*, 180, 1145-1146 (23 November 1957)
 - MacKay, D. M., “Visual effects of non-redundant stimulation,” *Nature*, 192, No. 4804, 739-740 (25 November 1961)
 - Fiorentini, A., and D. M. MacKay, “Temporal factors in pattern vision,” *Quarterly Journal of Experimental Psychology*, 17, Part 4, 282-291 (November 1965)

- MacKay, D. M., “Visual noise as a tool of research,” *Journal of General Psychology*, 72, 181-197 (1965)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 240-241
- Ross, J., “Stereopsis by binocular delay,” *Nature*, 248, 363-364 (22 March 1974)
- MacDonald, R. I., ““ cyclopean effect,” *Nature*, 249, No. 5453, 192 (10 May 1974)
- Tyler, C. W., “Stereopsis in dynamic visual noise,” *Nature*, 250, 781-782 (30 August 1974)
- Tyler, C. W., “Observations on binocular spatial frequency reduction in random noise,” *Perception*, 4, 305-309 (1975)
- Lappin, J. S., and H. H. Bell, “The detection of coherence in moving random-dot patterns,” *Vision Research*, 16, 161-168 (1976)
- Hogben, J. H., B. Julesz and J. Ross, “Short-term memory for symmetry,” *Vision Research*, 16, 861-866 (1976)
- Tyler, C. W., “Stereomovement for interocular delay in dynamic visual noise: a random spatial disparity hypothesis,” *American Journal of Optometry and Physiological Optics*, 54, No. 6, 374-386 (June 1977)
- Mezrich, J. J., and A. Rose, “Coherent motion and stereopsis in dynamic visual noise,” *Vision Research*, 17, 903-910 (1977)
- MacDonald, R. I., “Temporal stereopsis and dynamic visual noise,” *Vision Research*, 17, 1127-1128 (1977)
- MacKay, D. M., “The time-course of induction of complementary images,” *Vision Research*, 18, 913-916 (1978)
- MacDonald, R. I., “Three-dimensional television by texture parallax,” *Applied Optics*, 17, 168-170 (15 January 1978)
- Burr, D. C., and J. Ross, “How does binocular delay give information about depth?” *Vision Research*, 19, 523-532 (1979)
- MacKay, D. M., “Clues to the site of origin of the complementary image,” *Nature*, 279, 553 (7 June 1979)
- MacKay, D. M., H. J. M. Gerrits and H. P. W. Stassen, “Interaction of stabilized retinal patterns with spatial visual noise,” *Vision Research*, 19, 713-716 (1979)
- Hirst, A. N., R. L. Beurle, K. I. Beverley and C. L. Poole, “Contrast thresholds for patterns of dynamic visual noise,” *Vision Research*, 19, 721-725 (1979)
- Morgan, M. J., and R. Ward, “Conditions for motion flow in dynamic visual noise,” *Vision Research*, 20, 431-435 (1980)

- Walker, J., “Visual illusions in random-dot patterns and television 'snow'” in “The Amateur Scientist,” *Scientific American*, 242, 172-178 (April 1980)
- Walker, J., “Illusions in the snow: more fun with random dots on the television screen” in “The Amateur Scientist,” *Scientific American*, 242, 176-186 (May 1980)
- Foster, D. H., J. Thorson, J. T. McIlwain and M. Biederman-Thorson, “The fine-grain movement illusion: a perceptual probe of neuronal connectivity in the human visual system,” *Vision Research*, 21, 1123-1128 (1981)
- Hoffman, D. D., “Inferring local surface orientation from motion fields,” *Journal of the Optical Society of America*, 72, No. 7, 888-892 (July 1982)
- Baker Jr., C. L., and O. J. Braddick, “The basis of area and dot number effects in random dot motion perception,” *Vision Research*, 22, No. 10, 1253-1259 (1982)
- De Jonge, A. B., “A visual illusion of movement,” *Vision Research*, 22, 1413 (1982)
- Zeevi, Y. Y., and A. Medina, “Acceleration perceived with dynamic visual noise,” *Journal of the Optical Society of America A*, 1, No. 5, 562-564 (May 1984)
- Zeevi, Y. Y., and G. A. Geri, “A purely central movement aftereffect induced by binocular viewing of dynamic visual noise,” *Perception & Psychophysics*, 38, 433-437 (1985)

7.31 Mona Lisa’s smile

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

The material here is located at www.flyingcircusofphysics.com and will be updated periodically.

[http://www.harley.com/art/abstract-art/images/\(davinci\)-mona-lisa.jpg](http://www.harley.com/art/abstract-art/images/(davinci)-mona-lisa.jpg) The Mona Lisa

References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages

- Kontsevich, L. L., and C. W. Tyler, “What makes Mona Lisa smile?” *Vision Research*, 44, 1493-1498 (2004)
- “Noisy secret of Mona Lisa’s smile,” *New Scientist*, ??, (June 2004)

7.32 Floating, ghostly images of a television screen

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Crookes, T. G., “Television images,” *Nature*, 179, 1024-1025 (1957)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, pages 219-222
- Walker, J., “More about random-dot displays, plus computer programs to generate them” in “The Amateur Scientist,” *Scientific American*, 243, 198 (November 1980), see pages 206-210
- Walker, J., “The Amateur Scientist,” *Scientific American*, 245, 176-187 (July 1981), see pages 186-187
- Distelmaier, H., and G. Doerfel, “Apparent slant of moving targets on T.V. screens,” *Vision Research*, 25, 993-995 (1985)
- Little, J., letter, “The Last Word,” *New Scientist*, ??, inside back cover, (??)

7.33 Reading through pinholes

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Mathur, S. S., and R. D. Bahuguna, “Reading with the relaxed eye,” *American Journal of Physics*, 45, No. 11, 1097-1098 (November 1977)
- Klinger, J. D., “Apparent improvement of TV picture quality through narrow pupils independent of overall quantal flux reduction,” *Perception*, 7, 725-726 (1978)
- Keating, M. P., “Reading through pinholes: a closer look,” *American Journal of Physics*, 47, No. 10, 889-891 (October 1979)
- Murphy, C. J., and H. C. Howland, “On the gekko pupil and Scheiner's disc,” *Vision Research*, 26, No. 5, 815-817 (1986)
- Barns, G., “A lizard's pinhole camera and related desert optics,” *Physics Teacher*, 27, 680 (1989)
- Colicchia, G., “Ancient cephalopod scavenges successfully with its pinhole eye,” *Physics Education*, 41, No. 1, 15-17 (January 2006)
- Shuttleworth, M., “Keep focused” in “The Last Word,” *New Scientist*, 195, No. 2623, inside back cover (29 September 2007)
- Colicchia, G., M. Hopf, H. Wiesner, and D. Zollman, “Pinhole glasses,” *Physics Teacher*, 46, No. 1, 26-28 (January 2008)
- Cepic, M., A. G. Blagotinsek, and N. Razpet, “Looking through pinhole glasses with a digital camera,” in “Little Gems” edited by C. Chiaverina, *Physics Teacher*, 46, 186-187 (March 2008)

7.34 Finger colors

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Helmholtz, H. von, *Physiological Optics*, volume 1, J. P. C. Southall, editor, Dover, 1962, pages 175-176

- Jacobs, S. F., and A. B. Stewart, “Chromatic aberration in the eye,” *American Journal of Physics*, 20, 247-248 (1952)
- Sivak, J. G., and T. Mandelman, “Chromatic dispersion of the ocular media,” *Vision Research*, 22, 997-1003 (1982)
- Walker, J., “The hyperscope and the pseudoscope aid experiments on three-dimensional vision,” in “The Amateur Scientist,” *Scientific American*, 255, No. 5, 134-140 (November 1986) Available at: http://www.phantascope.co.uk/pages/further_theHypAndPseud.html
- Edge, R. D., “The optics of the eye lens,” *Physics Teacher*, 27, 392-393 (May 1989)

Related reference

- Millodot, M., and A. Lamont, “Refraction of the periphery of the eye,” *Journal of the Optical Society of America*, 64, No. 1, 110-111 (January 1974)

7.35 Stars seen through a shaft during the daytime

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Hynek, J. A., “Photographing stars in the daytime,” *Sky & Telescope*, 10, 61-62 (1951)
 - Tousey, R., and M. J. Koomen, “The visibility of stars and planets during twilight,” *Journal of the Optical Society of America*, 43, No. 3, 177-183 (March 1953)
 - Smith, A. G., “Daylight visibility of stars from a long shaft,” *Journal of the Optical Society of America*, 45, No. 6, 482-483 (June 1955)
 - Wagenaar, L., “Visibility of planets during daylight,” *Journal of the Optical Society of America*, 56, No. 3, 406 (March 1966)

- Hughes, D. W., “On seeing stars (especially up chimneys),” *Quarterly Journal of the Royal Astronomical Society*, 24, 246-257 (1983)
- Schaefer, B. E., “Glare and celestial visibility,” *Publications of the Astronomical Society of the Pacific*, 103, 645-660 (July 1991)
- Sanderson, R., “Observing stars during the daytime: the chimney myth,” *Skeptical Inquirer*, 17, 74-77 (Fall 1992)
- Fentress, S. S., (letter) “Daytime stars,” *Skeptical Inquirer*, 17, No. 3, 338 (Spring 1993)
- Lynch, D. K., and W. Livingston, *Color and Light in Nature*, 2nd edition, Cambridge University Press, 2001, page 223

7.36 A stargazer's eye sweep

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Barrett, A. A., “Aristotle and averted vision,” *Journal of the Royal Astronomical Society of Canada*, 71, 327 (1977)
- Kaufman, L., *Perception: The World Transformed*, Oxford University Press, 1979, pages 33-34
- Bowen, K. P., “Vision and the amateur astronomer,” *Sky & Telescope*, ??, 321-324 (April 1984)

7.37 Resolution of earth objects by astronauts

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Boeke, K., *Cosmic View, the Universe in 40 Jumps*, John Day Co., Inc., New York, 1957
- Kilston, S., C. Sagan, and R. Drummond, “A Search for life on Earth at kilometer resolution,” *Icarus*, 5, 79-98 (1966)
- Wood, E., *Science for the Airplane Passenger*, Houghton Mifflin, 1968, pages 182-184
- “Discrete light sources observed by satellite OSO-B,” *Science*, 161, 459-460 (2 August 1968)
- Parmenter, F. C., “Trans-Canada highway,” *Monthly Weather Review*, 98, 252 (1970)
- Lunde, B. K., “Clouds associated with an interstate highway,” *Weatherwise*, 26, 122-123 (1973)
- Rango, A., J. L. Foster, V. V. Salomonson, “Comments on 'Clouds associated with an interstate highway',” *Weatherwise*, 26, 222 (1973)
- Croft, T. A., “Nighttime images of the Earth from space,” *Scientific American*, 239, No. 1, 86- (July 1978)
- Garriott, O. K., “Visual observations from space,” *Journal of the Optical Society of America*, 69, 1064-1068 + plates 113-115 (1979)
- Sagan, C., W. R. Thompson, R. Carlson, D. Gurnett, and C. Hord, “A search for life on Earth from the Galileo spacecraft,” *Nature*, 365, No. 6448, 715-721 (21 October 1993)

7.38 Honeybees, desert ants and polarized light

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Kalmus, H., "Orientation of animals to polarized light," *Nature*, 184, No. 4682, 228-230 (25 July 1959)
- Kennedy, D., and E. R. Baylor, "Analysis of polarized light by the bee's eye," *Nature*, 191, No. 4783, 34-37 (1 July 1961)
- Waterman, T., "Polarized light and animal navigation," *Scientific American*, 193, No. 1, 88-94 (July 1955); also in *Polarized Light* published by the American Institute of Physics, 1963, pages 18-23
- Shurcliff, W. A., and S. S. Ballard, *Polarized Light*, D. Van Nostrand, 1964, page 98
- Lockley, R. M., *Animal Navigation*, Hart, New York, 1967, chapters 13 and 14
- Frisch, K. von, *The Dance Language and Orientation of Bees*, Harvard University Press, 1967
- Snyder, A. W., and C. Pask, "How bees navigate," *Nature*, 239, 48-50 (1 September 1972)
- Gribakin, F. G., "Perception of polarised light in insects by filter mechanism," *Nature*, 246, 357-358 (7 December 1973)
- Wellington, W.G., "Bumblebee ocelli and navigation at dusk," *Science*, 183, 550-551 (8 February 1974)
- Duelli, P., "A fovea for E-vector orientation in the eye," *Journal of Comparative Physiology*, 102, 43- (1975)
- Wehner, R., G. D. Bernard and E. Geiger, "Twisted and non-twisted rhabdoms and their significance for polarization detection in the bee," *Journal of Comparative Physiology*, 104, No. 3, 225-245 (1975)
- Wehner, R., "Polarized-light navigation by insects," *Scientific American*, 235, No. 1, 106-115 + 138 (July 1976)
- Dyer, F. C., and J. L. Gould, "Honey bee navigation," *American Scientist*, 71, 587-597 (November-December 1983)
- Rossel, S., and R. Wehner, "Polarization vision in bees," *Nature*, 323, 128-131 (11 September 1986)
- Crane, H. R., "How does the honeybee sense polarization?" *Physics Teacher*, 27, 504-505 (October 1989)
- Wehner, R. and G. D. Bernard, "Photoreceptor twist: a solution to the false-color problem," *Proceedings of the National Academy of Sciences*, 90, 4132-4135 (May 1993)

- Day, S., “Corkscrew vision helps bees find flowers,” *New Scientist*, 139, 14 (31 July 1993)
- Land, M. E., “Old twist in a new tale,” *Nature*, 363, 581-582 (17 June 1993)
- Horvath, G., and D. Varju, “Polarization pattern of freshwater habitats recorded by video polarimetry in red, green and blue spectral ranges and its relevance for water detection by aquatic insects,” *Journal of Experimental Biology*, 200, 1155-1163 (1997)
- Kriska, G., G. Horvath, S. Andrikovics, “Why do mayflies lay their eggs *en masse* on dry asphalt roads? Water-imitating polarized light reflected from asphalt attracts Ephemeroptera,” *Journal of Experimental Biology*, 201, 2273-2286 (1998)
- Mitchell, A., “Polarized flight,” *Nature*, 394, No. 6692, 425 (20 July 1998)
- Wehner, R., “Polarization vision---a uniform sensory capacity?” *Journal of Experimental Biology*, 204, 2589-2596 (2001)
- Bernath, B., J. Gal, and G. Horvath, “Why is it worth flying at dusk for aquatic insects? Polarotactic water detection is easiest at low solar elevations,” *Journal of Experimental Biology*, 207, No. 5, 755-765 (2004)
- Shashar, N., S. Sabbah, and N. Aharoni, “Migrating locusts can detect polarized reflections to avoid flying over the sea,” *Biology Letters*, 1, No. 4, 472-475 (22 December 2005)
- Henze, M. J., and T. Labhart, “Haze, clouds and limited sky visibility: polarotactic orientation of crickets under difficult stimulus conditions,” *Journal of Experimental Biology*, 210, 3266-3276 (2007)
- Kriska, G., P. Malik, I. Szivak, and G. Horvath, “Glass buildings on river banks as ‘polarized light traps’ for mass-swarving polarotactic caddis flies,” *Naturwissenschaften*, 95, 461-467 (2008)

Related references

- Taylor, D. H., and K. Adler, “Spatial orientation by salamanders using plane-polarized light,” *Science*, 181, 285-287 (20 July 1973)
- Hawryshyn, C. W., “Polarization vision in fish,” *American Scientist*, 80, 164-175 (1992)
- Cameron, D. A., M. Rowe, C. W. Hawryshyn, (letters) “Polarized views,” *American Scientist*, 80, 211-212 (1992)
- Shashar, N., and T. W. Cronin, “Polarization contrast vision in octopus,” *Journal of Experimental Biology*, 199, 999-1004 (1996)

- Jprvatj. G., J. Gal, T. Labhart, and R. Wehner, “Does reflection polarization by plants influence colour perception in insects? Polarimetric measurements applied to a polarization-sensitive model retina of *Papilio* butterflies,” *Journal of Experimental Biology*, 205, 3281-3298 (2002)
- Horvath, G., J. Gal, T. Labhart, and R. Wehner, “Does reflection polarization by plants influence colour perception in insects? Polarimetric measurements applied to a polarization-sensitive model retina of *Papilio* butterflies,” *Journal of Experimental Biology*, 205, 3281-3298 (2002)
- Hegedus, R., and G. Horvath, “How and why are uniformly polarization-sensitive retinæ subject to polarization-related artifacts? Correction of some errors in the theory of polarization-induced false colours,” *Journal of Theoretical Biology*, 230, 77-87 (2004)

7.39 Haidinger's brush

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Minnaert, M., *Light and Colour in the Open Air*, Dover, 1954, pages 254-257
- Shurcliff, W. A., “Haidinger's brushes and circularly polarized light,” *Journal of the Optical Society of America*, 45, 399 (1955); also in *Polarized Light*, published by the American Institute of Physics, 1963, page 35
- Helmholtz, H. von, *Physiological Optics*, volume 2, J. P. C. Southall, editor, Dover, 1962, pages 304-307; also in *Polarized Light*, published by the American Institute of Physics, 1963, pages 30-34
- Shurcliff, W. A., and S. S. Ballard, *Polarized Light*, D. Van Nostrand, 1964, pages 95-97
- Seliger, H. H., and W. D. McElroy, *Light: Physical and Biological Action*, Academic Press, 1965, pages 300-304

- Summers, D. M., G. B. Friedmann, and R. M. Clements, "Physical model for Haidinger's brush," *Journal of the Optical Society of America*, 60, No. 2, 271-272 (February 1970)
- Shute, C. C. D., "Haidinger's brushes and redominant orientation of collagen in corneal stroma," *Nature*, 250, 163-164 (12 July 1974)
- Wang, T. J. Y., and F. A. Bettelheim, "Comparative birefringence of cornea," *Comparative Biochemistry and Physiology*, 51A, 89-94 (1975)
- Walker, J., "Studying polarized light with quarter-wave and half-wave plates of one's own making" in "The Amateur Scientist," *Scientific American*, 237, 172-180 + 190 (December 1977)
- Shute, C. C. D., "Letters," *Scientific American*, 238, 8 (April 1978)
- Walker, J., "The Amateur Scientist," *Scientific American*, 239, 140-146 (August 1978), see page 146
- Hochhimer, B., F., "Polarized light retinal photography of a monkey eye," *Vision Research*, 18, 19-23 (1978)
- Shute, C. C. D., "Haidinger's brushes," *Vision Research*, 18, 1467 (1978)
- Bone, R. A., "The role of the macular pigment in the detection of polarized light," *Vision Research*, 20, No. 3, 213-220 (1980)
- Gerharz, R., "On the enhancement of Haidinger's brush effect with color striations," *Optik*, 57, No. 2, 173-181 (1980)
- Bour, L. J., and N. J. L. Cardozo, "On the birefringence of the living human eye," *Vision Research*, 21, 1413-1421 (1981)
- Perenin, M. T., and E. Vadot, "Macular sparing investigated by means of Haidinger brushes," *British Journal of Ophthalmology*, 65, No. 6, 429-435 (1981)
- Stromeyer, III, C. F., J. B. Mulligan, D. G. Birch and B. M. Dawson, "Adaptation to polarized light in humans," *Vision Research*, 22, 217-223 (1982), see page 222
- Hemenger, R. P., "Dichroism of the macular pigment and Haidinger's brushes," *Journal of the Optical Society of America*, 72, No. 6, 734-737 (June 1982)
- Hochheimer, B. F., and H. A. Kues, "Retinal polarization effects," *Applied Optics*, 21, No. 21, 3811-3818 (1 November 1982)
- Bone, R. A., and J. T. Landrum, "Dichroism of lutein: a possible basis for Haidinger's brushes," *Applied Optics*, 22, No. 6, 775-776 (15 March 1983)
- Rea, M. S., "Effects of Haidinger's brushes on visual performance," *Journal of the Illuminating Engineering Society*, 12, No. 3, 197-203 (April 1983)

- Bone, R. A., and J. T. Landrum, “Macular pigment in Henle fiber membranes: a model for Haidinger's brushes,” *Vision Research*, 24, No. 2, 103-108 (1984)
- N’soukpoe-Kossi, C. N., and R. M. Leblanc, “Absorption and photoacoustic spectroscopies of lutein and zeaxanthin Langmuir-Blodgett films in connection with the Haidinger’s brushes,” *Canadian Journal of Chemistry-Revue Canadienne de Chimie*, 66, No. 6, 1459-1466 (June 1988)
- Edge, R. D., “The optics of the eye lens,” *Physics Teacher*, 27, 392-393 (May 1989)
- Reid, B., “Haidinger's brush,” *Physics Teacher*, 28, 598 (December 1990)
- Dodt, E., M. Kuba, “Visually evoked potentials in response to rotating plane-polarized blue light,” *Ophthalmic Research*, 22, No. 6, 391-394 (November-December 1990)
- Minnaert, M., *Light and Color in the Open Air*, translated and revised by L. Seymour, Springer-Verlag, 1993, pages 276-278, ISBN 0-387—97935-2, 3-540-97935-2, 0-387-94413-3
- Misson, G. P., “Form and behaviour of Haidinger’s brushes,” *Ophthalmic & Physiological optics: the Journal of the British College of Ophthalmic Opticians (Optometrists)*, 13, NO. 4, ?? (October 1993)
- Ovcharenko, A. P., and V. D. Yegorenkov, “Teaching students to observe Haidinger brushes,” *European Journal of Physics*, 23, 123-125 (2002)
- Misson, G. P., “A Mueller matrix model of Haidinger’s brushes,” *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians*, 23, 441-447 (2003)
- Rothmayer, M., W. Dultz, E. Frins, Q. Zhan, D. Tierney, and H. Schmitzer, “Nonlinearity in the rotational dynamics of Haidinger’s brushes,” *Applied Optics*, 46, No. 29, 7244-7251 (10 October 2007)

Related reference

- Cope, W. T., M. L. Wolbarsht, and B. S. Yamanashi, “The corneal polarization cross,” *Journal of the Optical Society of America*, 68, No. 8, 1139-1141 (August 1978)

7.40 Colors of shadows

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Padgham, C. A., and J. E. Saunders, *The Perception of Light and Colour*, G. Bell & Sons, 1975, pages 133-135
- Shute, C. C. D., “Subjective colours and brain function,” *Endeavour*, 5, No. 4, 141-146 (1981)
- Williamson, S. J., and H. Z. Cummins, *Light and Color in Nature and Art*, John Wiley, 1983, pages 330-331
- Churma, M. E., “Blue shadows: physical, physiological, and psychological causes,” *Applied Optics*, 33, No. 21, 4719-4722 + Plate 52 (July 1994), contained on Classic Reprints on CD-ROM Vol. 1, *On Minnaert’s Shoulders: Twenty Years of the “Light and Color” Conferences*, C. L. Adler editor, 1999, Optical Society of America, ISBN 1-55752-621-4; <http://www.osa.org>

7.41 Safety of sunglasses

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Sliney, D. H., and B. C. Freasier, “Evaluation of optical radiation hazards,” *Applied Optics*, 12, No. 1, 1-24 (January 1973)
- Anderson, W. J., and R. K. H. Gebel, “Ultraviolet windows in commercial sunglasses,” *Applied Optics*, 16, No. 2, 515-517 (February 1977)

- Segre, G., R. Reccia, B. Pignalosa and G. Pappalardo, “The efficiency of ordinary sunglasses as a protection from ultraviolet radiation,” *Ophthalmic Research*, 13, 180-187 (1981)
- Hoover, H. L., “Solar ultraviolet irradiation of human cornea, lens, and retina: equations of ocular irradiation,” *Applied Optics*, 25, No. 3, 359-368 (1 February 1986)
- Hoover, H. L., “Sunglasses, pupil dilation, and solar ultraviolet irradiation of the human lens and retina,” *Applied Optics*, 26, No. 4 689-695 (15 February 1987)
- Blumthaler, M., and W. Ambach, “How well do sunglasses protect against ultraviolet radiation?” *Lancet*, 337, 1284 (25 May 1991)
- Sliney, D. H., “Photoprotection of the eye---UV radiation and sunglasses,” *Journal of Photochemistry and Photobiology B: Biology*, 64, 166-175 (2001)
- Sliney, D. H., “How light reaches the eye and its components,” *International Journal of Toxicology*, 21, 501-509 (2002)
- DeBroff, B. M., and P. J. Pahk, “The ability of periorbitally applied antiglare products to improve contrast sensitivity in conditions of sunlight exposure,” *Archives of Ophthalmology*, 121, No. 7, 997-1001 (July 2003)
- Sliney, D. H., “Exposure geometry and spectral environment determine photobiological effects on the human eye,” *Photochemistry and Photobiology*, 81, 483-489 (2005)

7.42 Fish lens

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Blest, A. D., and M. F. Land, “The physiological optics of *Dinopis subrufus* L. Koch: a fish-lens in a spider,” *Proceedings of the Royal Society of London B*, 196, 197-222 (1977)

- Land, M. F., “The optical mechanism of the eye of *Limulus*,” *Nature*, 280, 396-397 (2 August 1979)
- Edwards, D. D., “Taking a crab’s-eye view of the world,” *Science News*, 133, 167 (12 March 1988)
- Land, M. E., “The optics of animal eyes,” *Contemporary Physics*, 29, No. 5, 435-455 (1988)
- Jagger, W. S., “The optics of the spherical fish lens,” *Vision Research*, 32, No. 7, 1271-1284 (1992)
- Land, M. E., “The evolution of eyes,” *Annual Review of Neuroscience*, 15, 1-29 (1992)
- Dawkins, R., “The eye in a twinkling,” *Nature*, 368, 690-691 (21 April 1994)
- Gordon, J. M., “Spherical gradient-index lenses as perfect imaging and maximum power transfer devices,” *Applied Optics*, 39, No. 22, 3825-3832 (1 August 2000)
- Zuccarello, G., D. Scribner, R. Sands, and L. J. Buckley, “Materials for bio-inspired optics,” *Advanced Materials*, 14, No. 18, 1261-164 (16 September 2002)
- Land, M. F., and D.-E. Nilsson, *Animal Eyes*, Oxford University Press, 2002, see especially pages 42-44

Related references

- Towe, K. M., “Trilobite eyes: calcified lenses in vivo,” *Science*, 179, 1007-1009 (9 March 1973)
- Clarkson, E. N. K., and R. Levi-Setti, “Trilobite eyes and the optics of Des Cartes and Huygens,” *Nature*, 254, 663-667 (24 April 1975)
- Harkness, L., “Chameleons use accommodation cues to judge distance,” *Nature*, 267, No. 5609, 346-349 (26 May 1977)
- Horridge, G. A., “Insects which turn and look,” *Endeavour*, 1, No. 1, 7-17 (1977)
- Horridge, G. A., “The compound eye of insects,” *Scientific American*, 237, No. 1, 108-120 + 154 (July 1977)
- Snyder, A. W., and W. H. Miller, “Telephoto lens system of falconiform eyes,” *Nature*, 275, 127-129 (14 September 1978)
- Williams, D. S., and P. McIntyre, “The principal eyes of a jumping spider have a telephoto component,” *Nature*, 288, 578-580 (11 December 1980)
- Doujak, F. E., “Can a shore crab see a star?” *Journal of Experimental Biology*, 116, 385-393 (1985) ??ordered

- Marshall, N. J., “A unique colour and polarization vision system in mantis shrimps,” *Nature*, 333, 557-560 (9 June 1988)
- Hardie, R. C., “The eye of the mantid shrimp,” *Nature*, 333, 499-500 (9 June 1988)
- Cronin, T. W., and N.J. Marshall, “A retina with at least ten spectral types of photoreceptors in a mantis shrimp,” *Nature*, 339, 137-140 (11 May 1989)
- Bowmaker, J. K., “A shrimp’s kaleidoscopic world,” *Nature*, 339, 99-100 (11 May 1989)
- Horvath, G., “Geometric optics of trilobite eyes: a theoretical study of the shape of the aspherical interface in the cornea of schizochroal eyes of phacopid trilobites,” *Mathematical Biosciences*, 96, No. 1, 79-94 (September 1989)
- Fordyce, D., and T. W. Cronin, “Trilobite vision: a comparison of schizochroal and holochroal eyes with the compound eyes of modern arthropods,” *Paleobiology*, 19, No. 3, 288-303 (1993)
- Day, S., “Sharp-eyed shrimp has binocular vision,” *New Scientist*, ??, 21 (11 June 1994)
- Nilsson, D.-E., and R. F. Modlin, “A mysid shrimp carrying a pair of binoculars,” *Journal of Experimental Biology*, 189, 213-236 (1994)
- Ott, M., and F. Schaeffel, “A negatively powered lens in the chameleon,” *Nature*, 373, 692-694 (23 February 1995)
- Chown, M., “I spy with my lobster eye,” *New Scientist*, ??, 20, (13 April 1996)
- Gal, J., G. Horvath, E. N. K. Clarkson, and O. Haiman, “Image formation by bifocal lenses in a trilobite eye?” *Vision Research*, 40, 843-853 (2000)
- Aizenberg, J., A. Tkachenko, S. Weiner, L. Addadi, and G. Hendler, “Calcitic microlenses as part of the photoreceptor system in brittlestars,” *Nature*, 412, 819-822 (23 August 2001)
- Humphries, S., and G. D. Ruxton, “Why did some ichthyosaurs have such large eyes?” *Journal of Experimental Biology*, 205, 439-441 (2002)
- Bruton, D. L., and W. Haas, “The puzzling eye of *phacops*,” *Special Papers in Palaeontology*, 70, 349-361 (2003)
- Rudkin, D. M., G. A. Young, R. J. Elias, and E. P. Dobrzanski, “The world’s biggest trilobite---*Isotelus rex* new species from the Upper Ordovician of Northern Manitoba, Canada,” *Journal of Paleontology*, 77, No. 1, 99-112 (2003)
- Fortey, R. A., “The lifestyles of the trilobites,” *American Scientist*, 92, No. 5, 446-?? (September-October 2004)

7.43 Depth in red and blue signs

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Vos, J. J., “Some new aspects of color stereoscopy,” *Journal of the Optical Society of America*, 50, 785-790 (August 1960)
- Vos, J. J., “An antagonistic effect in colour stereoscopy,” *Ophthalmologica*, 142, No. 1963, 442-445 (1963)
- Kishto, B. N., “The colour stereoscopic effect,” *Vision Research*, 5, 313-329 (1965)
- Oster, G., “Optical art,” *Applied Optics*, 4, No. 11, 1359-1369 (November 1965), see page 1361
- Vos, J. J., “The colour stereoscopic effect,” *Vision Research*, 6, 105-106 (1966); B. N. Kishto, reply, pages 106-107
- Sundet, J. M., “The effect of pupil size variations on the colour stereoscopic phenomenon,” *Vision Research*, 12, 1027-1032 (1972)
- Robinson, J. O., *The Psychology of Visual Illusion*, Hutchinson, 1972, page 250
- Edge, R., and E. R. Jones, “Why do red and blue lines move in opposite directions?” *Physics Teacher*, 22, 462-464 (1984)
- Hodych, J. P., “A large convex lens can provide stereoscopic views of maps colour coded in spectral order,” *Canadian Journal of Earth Science*, 22, 1877-1880 (1985)
- Walker, J., “The hyperscope and the pseudoscope aid experiments on three-dimensional vision,” in “The Amateur Scientist,” *Scientific American*, 255, No. 5, 134-140 (November 1986). Available at http://www.phantascope.co.uk/pages/further_theHypAndPseud.html
- Thompson, P., K. May, and R. Stone, “Chromostereopsis: a multicomponent depth effect?” *Displays*, 14, No. 4, 227-234 (October 1993)

7.44 Purkinje's blue arcs

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References

Dots • through ••• indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Dolecek, R. L., and J. de Launay, "Entoptic mapping of the Purkinje blue arcs," *Journal of the Optical Society of America*, 35, 676-680 (1945)
- Alpern, M., and D. Dudley, "The blue arcs of the retina," *Journal of General Physiology*, 49, 405-421 (1966)
- Moreland, J. D., "On demonstrating the blue arcs phenomenon," *Vision Research*, 8, 99-107 (1968)
- Moreland, J.D., "Threshold measurements of the blue arcs phenomenon," *Vision Research*, 8, 1093-1106 (1968)
- Moreland, J. D., "Possible mechanisms of the blue arcs of the retina," *Journal of Physiology*, 201, 60P-61P (April 1969)
- Moreland, J. D., "Retinal topography and the blue-arcs phenomenon," *Vision Research*, 9, 965-976 (1969)
- Ingling, C. R., and B. A. Drum, "Why the blue arcs of the retina are blue," *Vision Research*, 17, 498-500 (1977)
- Trezona, P. W., "Rod participation in the 'blue' mechanism and its effect on colour matching," *Vision Research*, 10, 317-332 (1970), see pages 328 ff
- Walker, J., "How to stop a spinning object by humming and perceive curious blue arcs around a light" in "The Amateur Scientist," *Scientific American*, 250, No. 2, 136-145 (February 1984)

7.45 Maxwell's spot

This item is discussed in the book *The Flying Circus of Physics, second edition*, by Jearl Walker, published by John Wiley & Sons, June 2006, ISBN 0-471-76273-3.

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Isobe, K., and K. Motokawa, “Functional structure of the retinal fovea and Maxwell's spot,” *Nature*, 175, 306-307 (1955)
- Brindley, G. S., “Entoptic images and related phenomena,” *Physiology of the Retina and Visual Pathway*, Williams & Wilkins Co., 1970
- Trezona, P. W., “Rod participation in the 'blue' mechanism and its effect on colour matching,” *Vision Research*, 10, 317 (1970), see pages 328 ff
- Palmer, D. A., “Maxwell spot and additivity in tetrachromatic matches,” *Journal of the Optical Society of American*, 68, No. 11, 1501-1505 (November 1978)
- Walker, J., “Floaters': visual artifacts resulting from blood cells in front of the fovea” in “The Amateur Scientist,” *Scientific American*, 246, 150-162 (April 1982)
- Lynch, D. K., and W. Livingston, *Color and Light in Nature*, 2nd edition, Cambridge University Press, 2001, page 237

7.46 Visual sensations from radiation

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- D'Arcy, F. J., and N. A. Porter, “Detection of cosmic ray mu-mesons by the human eye,” *Nature*, 196, 1013-1014 (1962)
- Wang, T.J., “Visual response of the human eye to X radiation,” *American Journal of Physics*, 35, 779 (1967)
- Fukui, K., Y. K. Lim and P. S. Young, “Cosmic-ray heavy-nucleus enders at various atmospheric depths,” *Nuovo Cimento B*, 210-219 (1969)

- Fremlin, J. H., "Cosmic ray flashes," *New Scientist*, 47, 42 (1970)
- Fazio, G. G., J. V. Jelley, and W. N. Charman, "Generation of Cherenkov light flashes by cosmic radiation within the eyes of the Apollo astronauts," *Nature*, 118, 260-264 (1970)
- Schaefer, H. J., "Radiation exposure in air travel," *Science*, 173, 780-783 (1971)
- Budinger, T. F., H. Bichsel and C. A. Tobias, "Visual phenomena noted by human subjects in exposure to neutrons of energies less than 25 million electron volts," *Science*, 172, 868-870 (1971)
- Charman, W. N., J. A. Dennis, G. G. Faxio and J. V. Jelley, "Visual sensations produced by single fast particle," *Nature*, 230, 522-524 (1971)
- Tobias, C. A., T. F. Budinger and J. T. Lyman, "Radiation-induced light flashes observed by human subjects in fast neutron, X-ray and positive pion beams," *Nature*, 230, 596-598 (1971)
- McAulay, I. R., "Cosmic ray flashes in the eye," *Nature*, 232, 421-422 (1971)
- Charman, W. N., and C. M. Rowlands, "Visual sensations produced by cosmic ray muons," *Nature*, 232, 574-575 (1971)
- McNulty, P. J., "Light flashes produced in the human eye by extremely relativistic muon," *Nature*, 234, 110 (1971)
- Burch, W. M., "Cerenkov light from 32P as an aid to diagnosis of eye tumours," *Nature*, 234, 358 (1971)
- Budinger, T. F., J. T. Lyman and C. A. Tobias, "Visual perception of accelerated nitrogen nuclei interacting with the human retina," *Nature*, 239, 209-211 (1972)
- McNulty, P. J., V. P. Pease, L.S. Pinsky, V. P. Bond, W. Schimmerling and K. G. Vosburgh, "Visual sensations induced by relativistic nitrogen nuclei," *Science*, 178, 160-161 (1972)
- Young, P. S., and K. Fukui, "Predicting light flashes due to alpha-particle flux on SST planes," *Nature*, 241, 112-113 (1973)
- Pinsky, L. S., W. Z. Osborne, J. V. Bailey, R. E. Benson and L. F. Thompson, "Light flashes observed by astronauts on Apollo 11 through Apollo 17," *Science*, 183, 957-959 (1974)
- McNulty, P. J., V. P. Pease and V. P. Bond, "Visual sensations induced by Cerenkov radiation," *Science*, 189, 453-454 (1975)
- McNulty, P. J., and V. P. Pease, "Muon-induced visual sensations," *Journal of the Optical Society of America*, 66, 49-55 (1976)
- Rothwell, P. L., R. C. Filz and P. J. McNulty, "Light flashes observed on Skylab 4: the role of nuclear stars," *Science*, 193, 1002-1003 (1976)

- McNulty, P. J., V. P. Pease and V. P. Bond, “Visual phenomena induced by relativistic carbon ions with and without Cerenkov radiation,” *Science*, 201, 341-343 (1978)
- Casolino, M., M. P. De Pascale, A. Morselli, L. Narici, P. Picozza, V. Prigione, R. Sparvoli, O. Adriani, P. Spillantini, G. Castellini, S. Bartalucci, C. Catena, D. Conti, M. Ricci, E. Right, B. Spataro, G. Trenta, M. Durante, G. Gialanella, G. Grossi, M. Pugliese, G. Barbiellini, M. Boezio, A. Vacchi, N. Zampa, W. G. Sannita, L. Lopez, M. Peresson, S. Conforto, A. P. Burlina, C. Tanzarella, G. Alberici, L. Casoli, S. Cerdonio, A. Lenti, A. Galper, Y. Ozerov, A. Popov, V. Zemskov, V. Zverev, A. Alexandrov, S. Avdeev, and V. Shabelnikov, “Light flash observation in space: Experiment ELFO,” *Nuovo Cimento*, 19D, No. 10, 1601-1623 (October 1997)
- Bidoli, V., M. Casolino, M. P. De Pascale, G. Furano, A. Morselli, L. Narici, P. Picozza, E. Reali, R. Sparvoli, A. M. Galper, Yu. U. Ozerov, A. V. Popov, N. R. Vavilov, A. P. Alexandrov, S. V. Avdeev, Y. Baturin, Y. Budarin, G. Padalko, V. G. Shabelnikov, G. Barbellini, W. Bonvicini, A. Vacchi, N. Zampa, S. Bartalucci, G. Mazzenga, M. Ricci, O. Adriani, P. Spillantini, M. Boezio, P. Carlson, C. Fuglesang, G. Castellini, and W. G. Sannita, “Study of cosmic rays and light flashes on board Space Station MIR: The SilEye experiment,” *Advances in Space Research*, 25, No. 10, 2075-2079 (2000)
- Maponi, P., M. Ricci, B. Spataro, and F. Zirilli, “A syncytium model for the interpretation of the phenomenon of anomalous light flashes occurring in the human eye during space missions,” *Nuovo Cimento*, 116B, No. 10, 1173-1179 (October 2001)
- Sannita, W. G., L. Narici, P. Picozza, “Positive visual phenomena in space: A scientific case and a safety issue in space travel,” *Vision Research*, 46, 2159-2165 (2006)
- Clark, S., “Light fantastic,” *New Scientist*, 198, No. 2658, 39-41 (31 May 2008)

Related references

- Araki, T., “Radiation level measured by a portable Geiger-Muller counter at the altitude of commercial air routes,” *Japanese Journal of Applied Physics*, 34, 4276-4277 (1995)
- Dyer, C. S., and P. R. Truscott, “Cosmic radiation effects on avionics,” *Radiation Protection Dosimetry*, 86, No. 4, 337-342 (1999)

- Goldhagen, P., “Overview of aircraft radiation exposure and recent ER-2 measurements,” *Health Physics*, 79, No. 5, 526-544 (November 2000)
- Kendall, G. M., “Factors affecting cosmic-ray doses at aircraft altitudes,” *Health Physics*, 79, No. 5, 560-562 (November 2000)
- Tveten, U., T. Haldorsen, and J. Reitan, “Cosmic radiation and airline pilots: exposure pattern as a function of aircraft type,” *Radiation Protection Dosimetry*, 87, No. 3, 157-165 (2000)
- Simonsen, L. C., J. W. Wilson, M. H. Kim, and F. A. Cucinotta, “Radiation exposure for human Mars exploration,” *Health Physics*, 79, No. 5, 515-525 (2000)
- O’Sullivan, D., “Cosmic rays: an in-flight hazard?” *Physics World*, ??, 21-22 (May 2000)
- Lim, M. K., “Exposure of airline pilots and cabin crew to cosmic radiation during flight --- What’s the fuss?,” *Annals Academy of Medicine*, 30, 494-498 (2001)
- Ferrari, A., M. Pelliccioni, and T. Rancati, “Calculation of the radiation environment caused by galactic cosmic rays for determining air crew exposure,” *Radiation Protection Dosimetry*, 93, No. 2, 101-114 (2001)
- Lim, M. K., “Cosmic rays: are air crew at risk?” *Occupational and Environmental Medicine*, 59, 428-433 (2002); M. Bagshaw, “Commentary,” page 433
- Taylor, G., “Astrophysics and air travel,” *Physics World*, 16, No. 4, 20-21 (April 2003)
- Lewis, B. J., M., Desormeaux, A. R. Green, L. G. I. Bennett, A. Butler, M. McCall, and J. C. S. Vergara, “Assessment of aircrew radiation exposure by further measurements and model development,” *Radiation Protection Dosimetry*, 111, No. 2, 151-171 (2004)
- Sigurdson, A. J., and E. Ron, “Cosmic radiation exposure and cancer risk among flight crew,” *Cancer Investigation*, 22, No.5, 743-761 (2004)
- Lewis, B. J., M., L. G. I. Bennett, A. R. Green, A. Butler, M. Desormeaux, F. Kitching, M. J. McCall, B. Ellaschuk, and M. Pierre, “Aircrew dosimetry using the predictive code for aircrew radiation exposure (PCAIRE),” *Radiation Protection Dosimetry*, 116, Nos. 1-4, 320-326 (2005)
- Jones, J. B. L., R. D. Bentley, R. Hunter, R. H. A. Iles, G. C. Taylor, and D. J. Thomas, “Space weather and commercial airlines,” *Advances in Space Research*, 36, 2258-2267 (2005)
- Rafnsson, V., E. Olafsdottir, J. Jrafnelsson, H. Sasaki, A. Arnarsson, and F. Jonasson, “Cosmic radiation increase the risk of nuclear cataract in airline pilots,” *Archives of Ophthalmology*, 123, No. 8, 1102-1105 (August 2005)

- Buja, A., G. Mastrangelo, E. Perissinotto, F. Grigoletto, A. C. Frigo, G. Rausa, V. Marin, C. Canova, and F. Dominici, “Cancer incidence among female flight attendants: a meta-analysis of published data,” *Journal of Women’s Health*, 15, No. 1, 98-105 (2006)

7.47 Red light for control boards

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Williamson, S. J., and H. Z. Cummins, *Light and Color in Nature and Art*, John Wiley, 1983, page 170

7.48 Superman's x-ray vision

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References

- Dots • through ••• indicate level of difficulty
- Journal reference style: author, journal, volume, pages (date)
- Book reference style: author, title, publisher, date, pages
- Pittenger, J. B., “On the plausibility of Superman's x-ray vision,” *Perception*, 12, 635-639 (1983)

7.49 Fireworks illusion

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<http://www.pbs.org/wgbh/nova/fireworks/> Web site to go with PBS network Nova show

<http://library.thinkquest.org/15384/?tqskip1=1> More

<http://www.pbs.org/wgbh/nova/kaboom/> More

References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Daniels, J. D., “Pyrotechnic illusion,” *Nature*, 341, 492 (1989)
- Dickinson, W. R., W. Bains, and F. Pansera, (letters) “The great fireworks illusion,” *Nature*, 343, No. 6256, 320 (1990)

7.50 Looking at the ceiling

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References

Dots • through ●●● indicate level of difficulty

Journal reference style: author, journal, volume, pages (date)

Book reference style: author, title, publisher, date, pages

- Brogan, D., “Environmental orientation reversal for supine observers,” *Perception*, 12, 149-150 (1983)