Light-year

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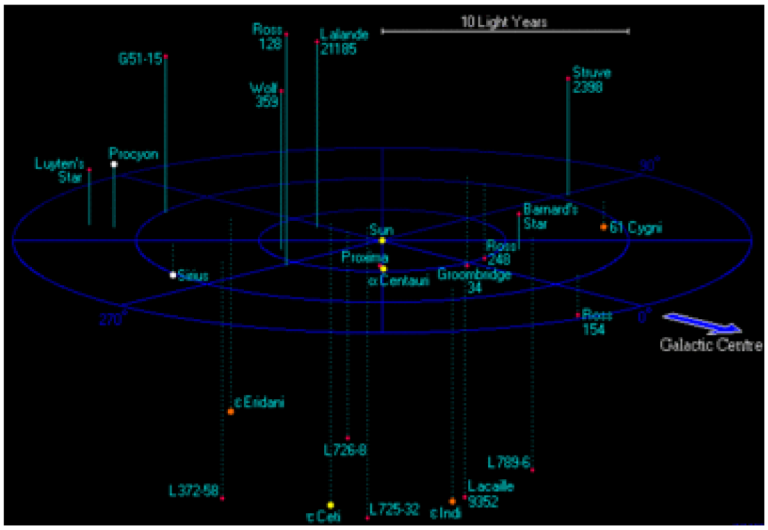
The **light-year** is a unit of length used to express astronomical distances. It is about 9.5 quadrillion metres or 5.9 trillion miles.[note 1] As defined by the International Astronomical Union (IAU), a light-year is the distance that light travels in vacuum in one Julian year (365.25 days).[2] Because it includes the word "year", the term light-year is sometimes misinterpreted as a unit of time.

The light-year is most often used when expressing distances to stars and other distances on a galactic scale, especially in nonspecialist and popular science publications. The unit usually used in professional astrometry is the parsec (symbol: pc, about 3.26 light-years; the distance at which one astronomical unit subtends an angle of one second of arc).[2]

Light-year



Map showing the stars that lie within **12.5 light-years** of the Sun[1]

Unit information	
Unit system	astronomy units
Unit of	length
Symbol	ly[2]
Unit conversions	
1 ly[2] *in ...*	*... is equal to ...*
metric (SI) units	9.4607×10^{15} m
imperial & US units	5.8786×10^{12} mi
astronomical units	63 241 au 0.3066 pc

Contents

Definitions

Look up ***light year*** in Wiktionary, the free dictionary.

As defined by the IAU, the light-year is the product of the Julian year[note 2] (365.25 days as opposed to the 365.2425-day Gregorian year) and the speed of light (299 792 458 m/s).[note 3] Both these values are included in the IAU (1976) System of Astronomical Constants, used since 1984.[4] From this, the following conversions can be derived. The IAU recognized abbreviation for light-year is ly,[2] although other standards like ISO 80000 uses "l.y."[5][6] and localized symbols are frequent, such as "al" in French (from ***année-lumière***) and Spanish (from ***año luz***), "Lj" in German (from ***Lichtjahr***), etc.

1 light-year = 9 460 730 472 580 800 metres (exactly)
≈ 9.461 petametres
≈ 9.461 trillion kilometres
≈ 5.878 625 trillion miles

≈ 63 241.077 astronomical units
≈ 0.306 601 parsecs

Before 1984, the tropical year (not the Julian year) and a measured (not defined) speed of light were included in the IAU (1964) System of Astronomical Constants, used from 1968 to 1983.[7] The product of Simon Newcomb's J1900.0 mean tropical year of 31 556 925.9747 ephemeris seconds and a speed of light of 299 792.5 km/s produced a light-year of $9.460\,530 \times 10^{15}$ m (rounded to the seven significant digits in the speed of light) found in several modern sources[8][9][10] was probably derived from an old source such as C. W. Allen's 1973 *Astrophysical Quantities* reference work,[11] which was updated in 2000, including the IAU (1976) value cited above (truncated to 10 significant digits).[12]

Other high-precision values are not derived from a coherent IAU system. A value of $9.460\,536\,207 \times 10^{15}$ m found in some modern sources[13][14] is the product of a mean Gregorian year (365.2425 days or 31 556 952 s) and the defined speed of light (299 792 458 m/s). Another value, $9.460\,528\,405 \times 10^{15}$ m,[15][16] is the product of the J1900.0 mean tropical year and the defined speed of light.

Abbreviations used for light years and multiples of light years are

- "ly" for one light year
- "Kly" for a kilolight-year (1,000 light years)
- "Mly" for a megalight-year (1,000,000 light years)
- "Gly" for a gigalight-year (1,000,000,000 light years)

History

The light-year unit appeared a few years after the first successful measurement of the distance to a star other than the Sun, by Friedrich Bessel in 1838. The star was 61 Cygni, and he used a 6.2-inch (160 mm) heliometer designed by Joseph von Fraunhofer. The largest unit for expressing distances across space at that time was the astronomical unit, equal to the radius of the Earth's orbit (1.50×10^8 km or 9.30×10^7 mi). In those terms, trigonometric calculations based on 61 Cygni's parallax of 0.314 arcseconds, showed the distance to the star to be 660 000 astronomical units (9.9×10^{13} km or 6.1×10^{13} mi). Bessel added that light employs 10.3 years to traverse this distance.[17] He recognized that his readers would enjoy the mental picture of the approximate transit time for light, but he refrained from using the light-year as a unit. He may have resented expressing distances in light-years because it would deteriorate the accuracy of his parallax data due to multiplying with the uncertain parameter of the speed of light. The speed of light was not yet precisely known in 1838; its value changed in 1849 (Fizeau) and 1862 (Foucault). It was not yet considered to be a fundamental constant of nature, and the propagation of light through the aether or space was still enigmatic. The light-year unit appeared, however, in 1851 in a German popular astronomical article by Otto Ule.[18] The paradox of a distance unit name ending on "year"' was explained by Ule by comparing it to a hiking road hour (*Wegstunde*). A contemporary German popular astronomical book also noticed that light-year is an odd name.[19] In 1868 an English journal labelled the light-year as a unit used by the Germans.[20] Eddington called the light-year an inconvenient and irrelevant unit, which had sometimes crept from popular use into technical investigations.[21]

Although modern astronomers often prefer to use the parsec, light years are also popularly used to gauge the expanses of interstellar and intergalactic space.

Usage of term

Distances expressed in light-years include those between stars in the same general area, such as those belonging to the same spiral arm or globular cluster. Galaxies themselves span from a few thousand to a few hundred thousand light-years in diameter, and are separated from neighbouring galaxies and galaxy clusters by millions of light-years. Distances to objects such as quasars and the Sloan Great Wall run up into the billions of light-years.

List of orders of magnitude for length

Scale (ly)	Value	Item
10^{-9}	40.4×10^{-9} ly	Reflected sunlight from the Moon's surface takes 1.2–1.3 seconds to travel the distance to the Earth's surface (travelling roughly 350 000 to 400 000 kilometres).
10^{-6}	15.8×10^{-6} ly	One astronomical unit (the distance from the Sun to the Earth). It takes approximately 499 seconds (8.32 minutes) for light to travel this distance.[22]
	127×10^{-6} ly	The Huygens probe lands on Titan off Saturn and transmits images from its surface 1.2 billion kilometres to the Earth.
	504×10^{-6} ly	New Horizons encounters Pluto at 4.7 billion kilometres and the communication takes 4 hours 25 minutes to reach Earth
10^{-3}	2.04×10^{-3} ly	The most distant space probe, Voyager 1, was about 18 light-hours away from the Earth as of October 2014.[23] It will take about 17 500 years to reach one light-year (1.0×10^{0} ly) at its current speed of about 17 km/s (38 000 mph) relative to the Sun. On September 12, 2013, NASA scientists announced that Voyager 1 had entered the interstellar medium of space on August 25, 2012, becoming the first manmade object to leave the Solar System.[24]
10^{0}	1.6×10^{0} ly	The Oort cloud is approximately two light-years in diameter. Its inner boundary is speculated to be at 50 000 au, with its outer edge at 100 000 au.
	2.0×10^{0} ly	Maximum extent of the Sun's gravitational dominance (Hill sphere/Roche sphere, 125 000 au). Beyond this is the deep ex-solar gravitational interstellar medium.
	4.22×10^{0} ly	The nearest known star (other than the Sun), Proxima Centauri, is about 4.22 light-years away.[25][26]
	8.60×10^{0} ly	Sirius, the brightest star of the night sky. Twice as massive and 25 times more luminous than the Sun, it outshines more luminous stars due to its relative proximity.
	11.90×10^{0} ly	HD 10700 e, an extrasolar candidate for a habitable planet. 6.6 times as massive as the earth, it is in the middle of the habitable zone of star Tau Ceti.[27][28]
	20.5×10^{0} ly	Gliese 581, a red-dwarf star with several detectable exoplanets.
	310×10^{0} ly	Canopus, second in brightness in the terrestrial sky only to Sirius, a type F supergiant 15 000 times more luminous than the Sun.
10^{3}	3×10^{3} ly	A0620-00, the nearest known black hole, is about 3000 light-years away.
	26×10^{3} ly	The centre of the Milky Way is about 26 000 light-years away.[29][30]
	100×10^{3} ly	The Milky Way is about 100 000 light-years across.
	165×10^{3} ly	R136a1, in the Large Magellanic Cloud, the most luminous star known at 8.7 million times the luminosity of the Sun, has an apparent magnitude 12.77, just brighter than 3C 273.
10^{6}	2.5×10^{6} ly	The Andromeda Galaxy is approximately 2.5 million light-years away.
	3×10^{6} ly	The Triangulum Galaxy (M33), at about 3 million light-years away, is the most distant object visible to the naked eye.
	59×10^{6} ly	The nearest large galaxy cluster, the Virgo Cluster, is about 59 million light-years away.
	150×10^{6} – 250×10^{6} ly	The Great Attractor lies at a distance of somewhere between 150 and 250 million light-years (the latter being the most recent estimate).
10^{9}	1.2×10^{9} ly	The Sloan Great Wall (not to be confused with Great Wall and Her–CrB GW) has been measured to be approximately one billion light-years distant.

	2.4×10^9 ly	3C 273, optically the brightest quasar, of apparent magnitude 12.9, just dimmer than R136a1. 3C 273 is about 2.4 billion light-years away.
	45.7×10^9 ly	The comoving distance from the Earth to the edge of the visible universe is about 45.7 billion light-years in any direction; this is the comoving radius of the observable universe. This is larger than the age of the universe dictated by the cosmic background radiation; see size of the universe: misconceptions for why this is possible.

Related units

Distances between objects within a star system tend to be small fractions of a light year, and are usually expressed in astronomical units. However, smaller units of length can similarly be formed usefully by multiplying units of time by the speed of light. For example, the light-second, useful in astronomy, telecommunications and relativistic physics, is exactly 299 792 458 metres or $^1/_{31\ 557\ 600}$ of a light-year. Units such as the light-minute, light-hour and light-day are sometimes used in popular science publications. The light-month, roughly one-twelfth of a light-year, is also used occasionally for approximate measures.[31][32] The Hayden Planetarium specifies the light month more precisely as 30 days of light travel time.[33]

Light travels approximately one foot in a nanosecond; the term "light-foot" is sometimes used as an informal measure of time.[34]

See also

- 1 petametre (examples of distances on the order of one light-year)
- Einstein protocol
- Hubble length
- Orders of magnitude (length)
- Speed of light
- Distance measures (cosmology)

Notes

1. One trillion here is taken to be 10^{12} (one million million).
2. One Julian year is of exactly 365.25 days (or 31 557 600 s based on a day of exactly 86 400 SI seconds)[3]
3. The speed of light is exactly 299 792 458 m/s by definition of the metre.

References

1. The Universe within 12.5 Light Years: The Nearest Stars (http://www.atlasoftheuniverse.com/12lys.html)
2. International Astronomical Union, *Measuring the Universe: The IAU and Astronomical Units*, retrieved 10 November 2013
3. *IAU Recommendations concerning Units*
4. "Selected Astronomical Constants" (http://asa.usno.navy.mil/static/files/2009/Astronomical_Constants_2009.pdf) in *Astronomical Almanac*, p. 6.
5. ISO 80000-3:2006 Quantities and Units - Space and Time
6. IEEE/ASTM SI 10-2010, American National Standard for Metric Practice
7. P. Kenneth Seidelmann, ed. (1992), *Explanatory Supplement to the Astronomical Almanac*, Mill Valey, California: University Science Books, p. 656, ISBN 0-935702-68-7
8. *Basic Constants*, Sierra College
9. Marc Sauvage, *Table of astronomical constants*
10. Robert A. Braeunig, *Basic Constants*
11. C. W. Allen (1973), *Astrophysical Quantities* (third ed.), London: Athlone, p. 16, ISBN 0-485-11150-0

12. Arthur N. Cox, ed. (2000), *Allen's Astrophysical Quantities* (fourth ed.), New York: Springer-Valeg, p. 12, ISBN 0-387-98746-0
13. Nick Strobel, *Astronomical Constants*
14. KEKB, *Astronomical Constants*
15. Thomas Szirtes (1997), *Applied dimensional analysis and modeling* New York: McGraw-Hill, p. 60, ISBN 9780070628113
16. *Sun, Moon, and Earth: Light-year*
17. Bessel, Friedrich (1839). "On the parallax of the star 61 Cygni". *London and Edinburgh Philosophical Magazine and Journal of Science*. **14**: 68–72. Retrieved 4 April 2014. Bessel's statement that light employs 10.3 years to traverse the distance.
18. Ule, Otto (1851). "Was wir in den Sternen lesen". *Deutsches Museum: Zeitschrift für Literatur, Kunst und Öffentliches Leben*. **1**: 721–738. Retrieved 4 April 2014.
19. Diesterweg, Adolph Wilhelm (1855). *Populäre Himmelskunde u. astronomische Geographie*. p. 250.
20. *The Student and Intellectual Observer of Science, Literature and Art*. Retrieved 1 November 2014.
21. "Stellar movements and the structure of the universe" Retrieved 1 November 2014.
22. "Chapter 1, Table 1-1", *IERS Conventions (2003)*
23. *WHERE ARE THE VOYAGERS?*, retrieved 14 October 2014
24. *NASA Spacecraft Embarks on Historic Journey Into Interstellar Space*, retrieved 14 October 2014
25. NASA, *Cosmic Distance Scales - The Nearest Star*
26. "Proxima Centauri (Gliese 551)", *Encyclopedia of Astrobiology, Astronomy, and Spaceflight*
27. "Tau Ceti's planets nearest around single, Sun-like star." *BBC News*. 19 December 2012 Retrieved 1 November 2014.
28. Tuomi, Mikko; Jones, Hugh R. A.; Jenkins, James S.; Tinney, Chris G.; Butler, R. Paul; Vogt, Steve S.; Barnes, John R.; Wittenmyer, Robert A.; O'Toole, Simon; Horner, Jonathan; Bailey, Jeremy; Carter, Brad D.; Wright, Duncan J.; Salter, Graeme S.; Pinfield, David (2012). "Signals embedded in the radial velocity noise: periodic variations in the τ Ceti velocities" (PDF). arXiv:1212.4277. Bibcode:2013A&A...551A..79T. doi:10.1051/0004-6361/201220509
29. Eisenhauer, F.; Schdel, R.; Genzel, R.; Ott, T.; Tecza, M.; Abuter, R.; Eckart, A.; Alexander, T. (2003), "A Geometric Determination of the Distance to the Galactic Center", *The Astrophysical Journal*, **597** (2): L121, arXiv:astro-ph/0306220, Bibcode:2003ApJ...597L.121E, doi:10.1086/380188
30. McNamara, D. H.; Madsen, J. B.; Barnes, J.; Ericksen, B. F. (2000), "The Distance to the Galactic Center" (PDF), *Publications of the Astronomical Society of the Pacific*, **112** (768): 202, Bibcode:2000PASP..112..202M, doi:10.1086/316512
31. Fujisawa, K.; Inoue, M.; Kobayashi, H.; Murata, Y.; Wajima, K.; Kameno, S.; Edwards, PG.; Hirabayashi, H.; Morimoto, M. (2000), "Large Angle Bending of the Light-Month Jet in Centaurus A", *Publ. Astron. Soc. Jpn.*, **52** (6): 1021–26, Bibcode:2000PASJ...52.1021F, doi:10.1093/pasj/52.6.1021
32. Junor, W.; Biretta, J. A. (1994), "The Inner Light-Month of the M87 Jet", in Zensus, J. Anton; Kellermann; Kenneth I., *Compact Extragalactic Radio Sources, Proceedings of the NRAO workshop held at Socorro, New Mexico, February 11–12, 1994*, Green Bank, WV: National Radio Astronomy Observatory (NRAO), p. 97, Bibcode:1994cers.conf...97J
33. Light-Travel Time and Distance by the Hayden Planetarium (http://www.haydenplanetarium.org/universe/duguide/app_light_travel_time_dista.php) Accessed October 2010.
34. David Mermin (2009). *It's About Time: Understanding Einstein's Relativity* Princeton, New Jersey: Princeton University Press. p. 22. ISBN 978-0-691-14127-5.

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