

Exhibit C

Epsilon Boötis

From Wikipedia, the free encyclopedia

Epsilon Boötis (**ε Boötis**, abbreviated **Epsilon Boo**, **ε Boo**), also named **Izar**,^[12] is a binary star in the northern constellation of Boötes. The star system can be viewed with the unaided eye at night, but resolving the pair with a small telescope is challenging; an aperture of 76 mm (3.0 in) or greater is required.^[13]

Contents

- 1 Nomenclature
- 2 Properties
- 3 In culture
- 4 References
- 5 External links

Nomenclature

ε Boötis (Latinised to *Epsilon Boötis*) is the star's Bayer designation.

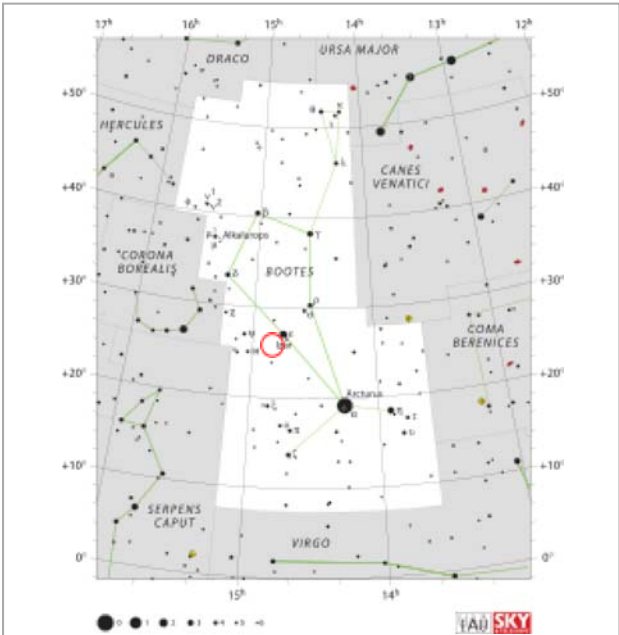
It bore the traditional names *Izar*, *Mirak* and *Mizar*, and was named *Pulcherrima* by Otto Struve.^[14] *Izar*, *Mirak* and *Mizar* are derived from the Arabic *إزار* *'izār* meaning 'veil' and *المراق* *al-maraqq* meaning 'the loins'; 'Pulcherrima' is Latin for 'loveliest'.^[15] In 2016, the International Astronomical Union organized a Working Group on Star Names (WGSN)^[16] to catalogue and standardize proper names for stars. The WGSN approved the name *Izar* for this star on 21 August 2016 and it is now so entered in the IAU Catalog of Star Names.^[12]

In the catalogue of stars in the *Calendarium of Al Achsasi Al Mouakket*, this star was designated *Mintek al Aoua* (منطقة العواء - *minṭāqa al awwa*), which was translated into Latin as *Cingulum Latratoris*, meaning *belt of barker*.^[17]

In Chinese, 梗河 (Gěng Hé), meaning *Celestial Lance*, refers to an asterism consisting of Epsilon Boötis, Sigma Boötis and Rho Boötis.^[18] Consequently, Epsilon Boötis itself is known as 梗河一 (Gěng Hé yī, English: the First Star of Celestial Lance.)^[19]

Properties

Epsilon Boötis A/B

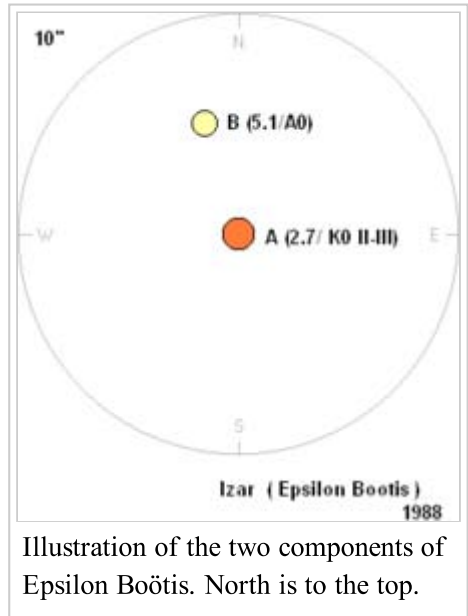


Location of ε Boötes (circled)

Observation data

	Epoch J2000	Equinox J2000
Constellation	Boötes	
Right ascension	14 ^h 44 ^m 59.21746 ^s ^[1]	
Declination	+27° 04′ 27.2099″ ^[1]	
Apparent magnitude (V)	2.37 ^[2] / 5.12 ^[3]	
Characteristics		
Spectral type	K0 II-III ^[4] + A2 V ^[5]	
U−B color index	+0.73 ^[2]	
B−V color index	+0.97 ^[2]	
Astrometry		
Radial velocity (R _v)	−16.31 ^[6] km/s	
Proper motion (μ)	RA: −50.95 ^[1] mas/yr Dec.: +21.07 ^[1] mas/yr	
Parallax (π)	16.10 ± 0.66 ^[1] mas	
Distance	203 ± 8 ly (62 ± 3 pc)	

Details



Hipparcos astrometry satellite^{[21][22]} put the system at a distance of about 203 light-years (62 parsecs) from the Earth.^[1] This means the pair has a projected separation of 185 Astronomical Units and they orbit each other with a period of at least 1,000 years.^[15]

The brighter member has a stellar classification of K0 II-III,^[4] which means it is a fairly late-stage star well into its stellar evolution, having already exhausted its supply of hydrogen fuel at the core. With more than four times the mass of the Sun,^[7] it has expanded to about 33 times the Sun's radius and is emitting 501 times the luminosity of the Sun.^[6] This energy is being radiated from its outer envelope at an effective temperature of 4,550 K,^[6] giving it the orange hue of a K-type star.^[23]

The companion star has a classification of A2 V,^[5] so it is a main sequence star that is generating energy through the thermonuclear fusion of hydrogen at its core. This star is rotating rapidly, with a projected rotational velocity of 123 km s⁻¹^[9] By the time the smaller main sequence star reaches the current point of the primary in its evolution, the larger star will have lost much of its mass in a planetary nebula and will have evolved into a white dwarf. The pair will have essentially changed roles: the brighter star becoming the dim dwarf, while the lesser companion will shine as a giant star.^[15]

In culture

In one *Star Trek* episode Whom Gods Destroy the major character Kelvar Garth is also referred to as Garth of Izar.

In 1973, the Scottish astronomer and science fiction writer Duncan Lunan claimed to have managed to interpret a message caught in the 1920s by two Norwegian physicists^[24] that, according to his theory, came from a probe orbiting the Moon and sent there by the inhabitants of a planet orbiting Epsilon Boötis.^[25] The story was even reported in *Time* magazine.^[26] Lunan later withdrew his Epsilon Boötis theory, presenting proofs against it and clarifying why he was brought to formulate it in the first place but would later go on to revoke his withdrawal.^[27]

Epsilon Boötis consists of a pair of stars with an angular separation of 2.852 ± 0.014 arcseconds at a position angle of $342.^{\circ}9 \pm 0.^{\circ}3$.^[20] The brighter component (A) has an apparent visual magnitude of 2.37,^[2] making it readily visible to the naked eye at night. The fainter component (B) is at magnitude 5.12,^[3] which by itself would also be visible to the naked eye. Parallax measurements from the

	A
Mass	4.6^[7] <i>M</i>_⊙
Radius	33^[6] <i>R</i>_⊙
Luminosity	501^[6] <i>L</i>_⊙
Surface gravity (log <i>g</i>)	2.2^[6] cgs
Temperature	4,550^[6] K
Metallicity	−0.13^[6]
Rotational velocity (<i>v</i> sin <i>i</i>)	10.9^[6] km/s
Age	37.4 ± 4.2^[8] Myr
	B
Rotational velocity (<i>v</i> sin <i>i</i>)	123^[9] km/s
Other designations	
Eps Boo, Izar, Pulcherrima, Mirac, Mirak, Mirach, 36 Boo, BD +27 2417, HIP 72105 ^[10]	
A: HD 129989, HR 5506, SAO 83500. ^[11]	
B: HD 129988, HR 5505. ^[3]	

References

1. van Leeuwen, F. (November 2007). "Validation of the new Hipparcos reduction". *Astronomy and Astrophysics*. **474** (2): 653–664. arXiv:0708.1752. Bibcode:2007A&A...474..653V. doi:10.1051/0004-6361:20078357.
2. Johnson, H. L.; et al. (1966). "UBVRIJKL photometry of the bright stars". *Communications of the Lunar and Planetary Laboratory*. **4** (99). Bibcode:1966CoLPL...4...99J.
3. "HR 5506 -- Star in double system", *SIMBAD*, Centre de Données astronomiques de Strasbourg, retrieved 2012-01-09
4. Luck, R. Earle; Wepfer, Gordon G. (November 1995), "Chemical Abundances for F and G Luminosity Class II Stars", *Astronomical Journal*, **110**: 2425, Bibcode:1995AJ....110.2425L, doi:10.1086/117702
5. Cowley, A.; et al. (April 1969), "A study of the bright A stars. I. A catalogue of spectral classifications", *Astronomical Journal*, **74**: 375–406, Bibcode:1969AJ....74..375C, doi:10.1086/110819
6. Massarotti, Alessandro; et al. (January 2008), "Rotational and Radial Velocities for a Sample of 761 Hipparcos Giants and the Role of Binarity", *The Astronomical Journal*, **135** (1): 209–231, Bibcode:2008AJ....135..209M, doi:10.1088/0004-6256/135/1/209
7. Gondoin, P. (December 1999), "Evolution of X-ray activity and rotation on G-K giants", *Astronomy and Astrophysics*, **352**: 217–227, Bibcode:1999A&A...352..217G
8. Tetzlaff, N.; Neuhäuser, R.; Hohle, M. M. (January 2011), "A catalogue of young runaway Hipparcos stars within 3 kpc from the Sun", *Monthly Notices of the Royal Astronomical Society*, **410** (1): 190–200, arXiv:1007.4883. Bibcode:2011MNRAS.410..190T, doi:10.1111/j.1365-2966.2010.17434.x
9. Royer, F.; et al. (October 2002), "Rotational velocities of A-type stars in the northern hemisphere. II. Measurement of $v \sin i$ ", *Astronomy and Astrophysics*, **393**: 897–911, arXiv:astro-ph/0205255. Bibcode:2002A&A...393..897R, doi:10.1051/0004-6361:20020943
10. "CCDM J14449+2704AB", *SIMBAD*, Centre de Données astronomiques de Strasbourg, retrieved 2012-01-09
11. "HR 5505 -- Star in double system", *SIMBAD*, Centre de Données astronomiques de Strasbourg, retrieved 2012-01-09
12. "IAU Catalog of Star Names". Retrieved 28 July 2016.
13. Monks, Neale (2010), *Go-To Telescopes Under Suburban Skies*, Patrick Moore's Practical Astronomy Series, Springer, ISBN 1-4419-6850-4
14. Norton's Star Atlas, publ. Gall & Inglis, Edinburgh, 2nd Ed., 1959
15. Kaler, James B., "Izar", *Stars*, University of Illinois, retrieved 2012-01-09
16. "IAU working group on star names (WGSN)". Retrieved 22 May 2016.
17. Knobel, E. B. (June 1895), "Al Achsasi Al Mouakket, on a catalogue of stars in the Calendarium of Mohammad Al Achsasi Al Mouakket", *Monthly Notices of the Royal Astronomical Society*, **55**: 429, Bibcode:1895MNRAS..55..429K, doi:10.1093/mnras/55.8.429
18. **(Chinese)** 中國星座神話, written by 陳久金. Published by 台灣書房出版有限公司, 2005, ISBN 978-986-7332-25-7.
19. **(Chinese)** 香港太空館 - 研究資源 - 亮星中英對照表 (http://www.lcsd.gov.hk/CE/Museum/Space/Research/StarName/c_research_chinengstars_h_l.htm), Hong Kong Space Museum. Accessed on line November 23, 2010.
20. Prieur, J.-L.; et al. (June 2008), "Speckle observations with PISCO in Merate - V. Astrometric measurements of visual binaries in 2006", *Monthly Notices of the Royal Astronomical Society*, **387** (2): 772–782, Bibcode:2008MNRAS.387..772P, doi:10.1111/j.1365-2966.2008.13265.x
21. Perryman, M. A. C.; Lindegren, L.; Kovalevsky, J.; et al. (July 1997), "The Hipparcos Catalogue", *Astronomy and Astrophysics*, **323**: L49–L52, Bibcode:1997A&A...323L..49P
22. Perryman, Michael (2010), *The Making of History's Greatest Star Map*, Heidelberg: Springer-Verlag, doi:10.1007/978-3-642-11602-5
23. "The Colour of Stars", *Australia Telescope, Outreach and Education*, Commonwealth Scientific and Industrial Research Organisation, December 21, 2004, retrieved 2012-01-16
24. Holm, Sverre (March 16, 2004), *The Five Most Likely Explanations for Long Delayed Echoes*, retrieved 2009-09-01
25. "Spaceprobe from Epsilon Boötis" by Duncan Lunan, in "Spaceflight" (British Interplanetary Society), 1973
26. "Message from a Star", *Time*, April 9, 1973, retrieved 2009-08-27
27. Lunan, Duncan (March 1998), "Epsilon Boötis Revisited", *Analog Science Fiction and Fact*, **118** (3)

External links

- HR 5506 (<http://webviz.u-strasbg.fr/viz-bin/VizieR-S?HR%205506>)
- HR 5505 (<http://webviz.u-strasbg.fr/viz-bin/VizieR-S?HR%205505>)
- CCDM J14449+2704 (<http://webviz.u-strasbg.fr/viz-bin/VizieR-S?CCDM%20J14449%2b2704A>)

- Image Epsilon Boötis (<http://aladin.u-strasbg.fr/AladinPreview?-c=14+44+59.208%2B27+04+27.38&ident=HD+129989&submit=Aladin+previewer>)
- The Constellations and Named Stars (<http://www.purplehell.com/riddletools/stars.htm>)

Retrieved from "https://en.wikipedia.org/w/index.php?title=Epsilon_Boötis&oldid=747475668"

Categories: Binary stars | Flamsteed objects | Henry Draper Catalogue objects | Hipparcos objects
| Bayer objects | Boötes (constellation) | K-type bright giants | K-type giants | A-type main-sequence stars
| Stars with proper names

-
- This page was last modified on 2 November 2016, at 16:04.
 - Text is available under the Creative Commons Attribution-ShareAlike License; additional terms may apply. By using this site, you agree to the Terms of Use and Privacy Policy. Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a non-profit organization.