= Barnard 's Star =

Barnard 's Star / ?b??rn?rd / is a very @-@ low @-@ mass red dwarf about six light @-@ years away from Earth in the constellation of Ophiuchus . It is the fourth @-@ closest known individual star to the Sun (after the three components of the Alpha Centauri system) and the closest star in the Northern Hemisphere . Despite its proximity , at a dim apparent magnitude of about nine , it is not visible with the unaided eye ; however , it is much brighter in the infrared than it is in visible light .

The star is named after the American astronomer E. E. Barnard . He was not the first to observe the star (it appeared on Harvard University plates in 1888 and 1890) , but in 1916 he measured its proper motion as 10 @.@ 3 arcseconds per year , which remains the largest proper motion of any star relative to the Solar System .

Barnard 's Star is among the most studied red dwarfs because of its proximity and favorable location for observation near the celestial equator . Historically , research on Barnard 's Star has focused on measuring its stellar characteristics , its astrometry , and also refining the limits of possible extrasolar planets . Although Barnard 's Star is an ancient star , it still experiences star flare events , one being observed in 1998 .

The star has also been the subject of some controversy . For a decade , from the early 1960s to the early 1970s , Peter van de Kamp claimed that there were one or more gas giants in orbit around it . Although the presence of small terrestrial planets around Barnard 's Star remains a possibility , Van de Kamp 's specific claims of large gas giants were refuted in the mid @-@ 1970s .

= = Overview = =

Barnard 's Star is a red dwarf of the dim spectral type M4 , and it is too faint to see without a telescope . Its apparent magnitude is 9 @.@ 5 . This compares with a magnitude of ? 1 @.@ 5 for Sirius ? the brightest star in the night sky ? and about 6 @.@ 0 for the faintest objects visible with the naked eye (this magnitude scale is logarithmic , so the magnitude of 9 @.@ 54 is only about 1 / 27 of the brightness of the faintest star that can be seen with the naked eye (under good viewing conditions) .

At 7 ? 12 billion years of age , Barnard 's Star is considerably older than the Sun , which is 4 @.@ 5 billion years old , and it might be among the oldest stars in the Milky Way galaxy . Barnard 's Star has lost a great deal of rotational energy , and the periodic slight changes in its brightness indicate that it rotates once in 130 days (the Sun rotates in 25) . Given its age , Barnard 's Star was long assumed to be quiescent in terms of stellar activity . However , in 1998 , astronomers observed an intense stellar flare , surprisingly showing that Barnard 's Star is a flare star . Barnard 's Star has the variable star designation V2500 Ophiuchi . In 2003 , Barnard 's Star presented the first detectable change in the radial velocity of a star caused by its motion . Further variability in the radial velocity of Barnard 's Star was attributed to its stellar activity .

The proper motion of Barnard 's Star corresponds to a relative lateral speed of 90 km / s . The 10 @.@ 3 seconds of arc it travels annually amount to a quarter of a degree in a human lifetime , roughly half the angular diameter of the full Moon .

The radial velocity of Barnard 's Star towards the Sun is measured from its blue shift to be 110 km / s . Combined with its proper motion , this gives a true velocity relative to the Sun of 143 km / s . Barnard 's Star will make its closest approach to the Sun around AD 11 @,@ 800 , when it approaches to within about 3 @.@ 75 light @-@ years . However , at that time , Barnard 's Star will not be the nearest star , since Proxima Centauri will have moved even closer to the Sun . Barnard 's Star will still be too dim to be seen with the naked eye at the time of its closest approach , since its apparent magnitude will be about 8 @.@ 5 then . After that it will gradually recede from the Sun .

Barnard 's Star has a mass of about 0 @.@ 14 solar masses (M ?) , and a radius 15 % to 20 % of that of the Sun . Thus , although Barnard 's Star has roughly 150 times the mass of Jupiter (MJ) , its radius is only 1 @.@ 5 to 2 @.@ 0 times larger , due to its much higher density . Its effective temperature is 3 @,@ 100 kelvins , and it has a visual luminosity of 0 @.@ 0004 solar luminosities .

Barnard 's Star is so faint that if it were at the same distance from Earth as the Sun is , it would appear only 100 times brighter than a full moon , comparable to the brightness of the Sun at 80 astronomical units .

Barnard 's Star 's has 10 ? 32 % of the solar metallicity . Metallicity is the proportion of stellar mass made up of elements heavier than helium and helps classify stars relative to the galactic population . Barnard 's Star seems to be typical of the old , red dwarf population II stars , yet these are also generally metal @-@ poor halo stars . While sub @-@ solar , Barnard 's Star 's metallicity is higher than that of a halo star and is in keeping with the low end of the metal @-@ rich disk star range ; this , plus its high space motion , have led to the designation " intermediate population II star " , between a halo and disk star .

= = Claims of a planetary system = =

For a decade from 1963 to about 1973 , a substantial number of astronomers accepted a claim by Peter van de Kamp that he had detected , by using astrometry , a perturbation in the proper motion of Barnard 's Star consistent with its having one or more planets comparable in mass with Jupiter . Van de Kamp had been observing the star from 1938 , attempting , with colleagues at the Swarthmore College observatory , to find minuscule variations of one micrometre in its position on photographic plates consistent with orbital perturbations that would indicate a planetary companion ; this involved as many as ten people averaging their results in looking at plates , to avoid systemic individual errors . Van de Kamp 's initial suggestion was a planet having about 1 @.@ 6 MJ at a distance of 4 @.@ 4 AU in a slightly eccentric orbit , and these measurements were apparently refined in a 1969 paper . Later that year , Van de Kamp suggested that there were two planets of 1 @.@ 1 and 0 @.@ 8 MJ .

Other astronomers subsequently repeated Van de Kamp 's measurements , and two papers in 1973 undermined the claim of a planet or planets . George Gatewood and Heinrich Eichhorn , at a different observatory and using newer plate measuring techniques , failed to verify the planetary companion . Another paper published by John L. Hershey four months earlier , also using the Swarthmore observatory , found that changes in the astrometric field of various stars correlated to the timing of adjustments and modifications that had been carried out on the refractor telescope 's objective lens ; the claimed planet was attributed to an artifact of maintenance and upgrade work . The affair has been discussed as part of a broader scientific review .

Van de Kamp never acknowledged any error and published a further claim of two planets ' existence as late as 1982 ; he died in 1995 . Wulff Heintz , Van de Kamp 's successor at Swarthmore and an expert on double stars , questioned his findings and began publishing criticisms from 1976 onwards . The two men were reported to have become estranged from each other because of this .

= = = Refining planetary boundaries = = =

While not completely ruling out the possibility of planets , null results for planetary companions continued throughout the 1980s and 1990s , the latest based on interferometric work with the Hubble Space Telescope in 1999 . By refining the values of a star 's motion , the mass and orbital boundaries for possible planets are tightened : in this way astronomers are often able to describe what types of planets cannot orbit a given star .

M dwarfs such as Barnard 's Star are more easily studied than larger stars in this regard because their lower masses render perturbations more obvious . Gatewood was thus able to show in 1995 that planets with 10 MJ (the lower limit for brown dwarfs) were impossible around Barnard 's Star , in a paper which helped refine the negative certainty regarding planetary objects in general . In 1999 , work with the Hubble Space Telescope further excluded planetary companions of 0 @.@ 8 MJ with an orbital period of less than 1 @,@ 000 days (Jupiter 's orbital period is 4 @,@ 332 days) , while Kuerster determined in 2003 that within the habitable zone around Barnard 's Star , planets are not possible with an " M sin i " value greater than 7 @.@ 5 times the mass of the Earth (M ?) , or with a

mass greater than 3 @.@ 1 times the mass of Neptune (much lower than van de Kamp 's smallest suggested value) .

Even though this research has greatly restricted the possible properties of planets around Barnard 's Star , it has not ruled them out completely ; terrestrial planets would be difficult to detect . NASA 's Space Interferometry Mission , which was to begin searching for extrasolar Earth @-@ like planets , was reported to have chosen Barnard 's Star as an early search target . However , this mission was shut down in 2010 . ESA 's similar Darwin interferometry mission had the same goal , but was stripped of funding in 2007 .

= = Exploration = =

= = = Project Daedalus = = =

Barnard 's Star was studied as part of Project Daedalus . Undertaken between 1973 and 1978 , the study suggested that rapid , unmanned travel to another star system was possible with existing or near @-@ future technology . Barnard 's Star was chosen as a target partly because it was believed to have planets .

The theoretical model suggested that a nuclear pulse rocket employing nuclear fusion (specifically , electron bombardment of deuterium and helium @-@ 3) and accelerating for four years could achieve a velocity of 12 % of the speed of light . The star could then be reached in 50 years , within a human lifetime . Along with detailed investigation of the star and any companions , the interstellar medium would be examined and baseline astrometric readings performed .

The initial Project Daedalus model sparked further theoretical research . In 1980 , Robert Freitas suggested a more ambitious plan : a self @-@ replicating spacecraft intended to search for and make contact with extraterrestrial life . Built and launched in Jovian (Jupiter 's) orbit , it would reach Barnard 's Star in 47 years under parameters similar to those of the original Project Daedalus . Once at the star , it would begin automated self @-@ replication , constructing a factory , initially to manufacture exploratory probes and eventually to create a copy of the original spacecraft after 1 @,@ 000 years .

= = 1998 flare = =

In 1998 a stellar flare on Barnard 's Star was detected based on changes in the spectral emissions on July 17 , 1998 , during an unrelated search for variations in the proper motion . Four years passed before the flare was fully analyzed , at which point it was suggested that the flare 's temperature was 8000 K , more than twice the normal temperature of the star . Given the essentially random nature of flares , Diane Paulson , one of the authors of that study , noted that " the star would be fantastic for amateurs to observe " .

The flare was surprising because intense stellar activity is not expected in stars of such age . Flares are not completely understood , but are believed to be caused by strong magnetic fields , which suppress plasma convection and lead to sudden outbursts : strong magnetic fields occur in rapidly rotating stars , while old stars tend to rotate slowly . For Barnard 's Star to undergo an event of such magnitude is thus presumed to be a rarity . Research on the star 's periodicity , or changes in stellar activity over a given timescale , also suggest it ought to be quiescent ; 1998 research showed weak evidence for periodic variation in the star 's brightness , noting only one possible starspot over 130 days .

Stellar activity of this sort has created interest in using Barnard 's Star as a proxy to understand similar stars . It is hoped that photometric studies of its X @-@ ray and UV emissions will shed light on the large population of old M dwarfs in the galaxy . Such research has astrobiological implications : given that the habitable zones of M dwarfs are close to the star , any planets would be strongly influenced by solar flares , winds , and plasma ejection events .

= = Environment = =

Barnard 's Star shares much the same neighborhood as the Sun . The neighbors of Barnard 's Star are generally of red dwarf size , the smallest and most common star type . Its closest neighbor is currently the red dwarf Ross 154 , at 1 @.@ 66 parsecs (5 @.@ 41 light years) distance . The Sun and Alpha Centauri are , respectively , the next closest systems . From Barnard 's Star , the Sun would appear on the diametrically opposite side of the sky at coordinates RA = 5h 57m 48.5s , Dec = ? 04 ° 41 ? 36 ? , in the eastern part of the constellation Monoceros . The absolute magnitude of the Sun is 4 @.@ 83 , and at a distance of 1 @.@ 834 parsecs , it would be a first @-@ magnitude star , as Pollux is from the Earth .