SURPRISING RAPID COLLAPSE OF SIRIUS B FROM RED GIANT TO WHITE DWARF THROUGH MASS TRANSFER TO SIRIUS A

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Sirius was observed in antiquity as a red star. In his famous astronomy textbook the *Almagest* written 140 AD, Ptolemy described the star Sirius as fiery red. He curiously depicted it as one of six red-colored stars. The other five are class M and K stars, such as Arcturus and Betelgeuse.

Apparent confirmation in ancient Greek and Roman sources are found and Sirius was also reported red in Europe about 1400 years ago. Sirius must have changed to a white dwarf in the night of Ascension. The star chapter in the Quran started with "by the star as it collapsed (1) your companion have not gone astray nor being misled (2), and in verse 49 which is the rotation period of the companion Sirius B around Sirius A, it is said" He is the Lord of Sirius (49).

If Sirius actually was red what could have caused it to change into the brilliant bluish-white star we see today?

What the naked eye perceives as a single star is actually a binary star system , consisting of a white main sequence star of spectral type A1V, termed Sirius A, and a faint white dwarf companion of spectral type DA2, termed Sirius B.

The red color indicates that the star seen then was a red giant. It looks that what they have seen in antiquity was Sirius B which was then a red giant and it collapsed to form a white dwarf. Since there is no evidence of a planetary nebula, then the red Sirius paradox can be solved in terms of stellar evolution with mass transfer. Sirius B was the most massive star which evolved to a red giant and filled the Roche lobe. Mass transfer to Sirius A occurred through the Lagrangian point. Sirius A then became more massive while Sirius B lost mass and shrank. Sirius B then collapsed abruptly into a white dwarf.

In the case of Algol, Ptolmy observed it as white star but it was red at the time of El sufi. At present it is white.

The rate of mass transfer from Sirius B to Sirius A, and from Algol B to A is estimated from observational data of colour change from red to bullish white to be 0.0021 and 0.0024 $M_{\odot}$/ yr respectively.

INTRODUCTION

Wide spread observations of red Sirius were reported including the Babylon, the Ancient Egyptians Yousef 2010), the Greeks, the Romans etc. In his famous astronomy textbook the *Almagest* written 140 AD, Ptolemy described the star Sirius as *hypocirros*, ‘fiery red. He curiously depicted it as one of six red-colored stars.

In China, (145-87 BCE) there are indications of a change of color between yellow and red. In Thebes Egypt (2BCE), a change in color between white and red. For an extended review of Sirius red color see Holberg (2007).

In Medieval Europe 1400 years ago, Sirius was red (Schlosser and Bergman, 1985).

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MASS TRANSFER BETWEEN BINARY COMPANIONS

When a main sequence star exhaust its fuel in the core and expands into a red giant , it fills its Roche limit and matter overflow through the Lagrangian point into its companion either directly making a hot spot or forms an accretion disc. Illustration of mass transfer is given below

http://www.google.com.eg/imgres?imgurl=http://astro.physics.ncsu.edu

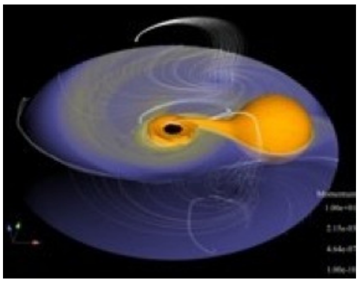

Fig. 1. The Sirius A and its white Dwarf companion.

1-THE RED SIRIUS PARADOX

In 1844, German astronomer Friedrich Bessel deduced from changes in the proper motion of Sirius that it had an unseen companion Nearly two decades later, on January 31, 1862, American telescope-maker and astronomer Alvan Graham Clark first observed the faint companion, which is now called Sirius B The visible star is now sometimes known as Sirius A. In 1915, Walter Sydney Adams, using a 60-inch (1.5 m) reflector at Mount Wilson Observatory, observed the spectrum of Sirius B and determined that it was a faint whitish star. This led astronomers to conclude that it was a white dwarf, the second to be discovered The diameter of Sirius A was first measured by Robert Hanbury Brown and Richard Q. Twiss in 1959 at Jodrell Bank using their stellar intensity interferometer. In 2005, using the Hubble Space Telescope, astronomers determined that Sirius B has nearly the diameter of the Earth, 12,000 kilometers with a mass that is 98% of the Sun Wikipedia and references therein. *Extreme Ultraviolet Explorer* (*EUVE*) observations and reprocessed *IUE* NEWSIPS data have produced a new, well-defined effective temperature of 24,790 ± 100 K and a surface gravity of log g = 8.57 ± 0.06 for Sirius B. A new *Hipparcos* parallax for the Sirius system of $\pi = 0''.37921 \pm 0''.00158$ is used in conjunction with the above spectroscopic results and the previously published gravitational redshift to yield a mass of 0.984 ± 0.074 $M_{\odot}$ and a radius of R = 0.0084 ± 0.00025$R_{\odot}$ for the white dwarf (Holberg et al. 1998).

Fig. 2. The Sirius A and its white Dwarf companion.

EXPLANATION OF THE RED CLOUR OF SIRIUS IN ANTIQUATY AND UP TILL 1400 Y AGO

First we will assume that the red color of Sirius in historical observation was due to the evolution of Sirius B in its red giant state. Sometimes Sirius was observed white. This can be explained either to a pulsating character of Sirius B. when it shrank, its surface temperature increased thus rendering a white color to the star. In this oscillatory mode, recurrent expansion of Sirius B would make it appear white. Repeated oscillation will alternate the color between red-orange and white. Finally the star became a red giant and filled the Roche lobe. Eventually matter started to flow through the Lagrange point into the less massive star Sirius A. All the envelope of the red giant was transferred to Sirius A like putting a shawl on it. This explains the high metalicity of Sirius A . Sirius A is classed as an Am star because the spectrum shows deep metallic absorption lines, indicating an enhancement in elements heavier than helium, such as iron. When compared to the Sun, the proportion of iron in the atmosphere of Sirius A relative to hydrogen is given by $[\frac{F_e}{H}]=0.5$, which is equivalent to $10^{0.5}$, meaning it has 316% of the proportion of iron in the Sun's atmosphere. The high surface content of metallic elements is unlikely to be true of the entire star. Instead these may be suspended by a thin convection zone at the surface (Wikipedia and references therein).

Most important is the paper by Schlosser and Bergman (1985) where they pointed out that Sirius was seen red 1400 years ago. Once The outer shell of Sirius B was wrapped around Sirius A, then the solid core of the star contracted instantaneously and the star collapsed under the lonely force of gravity in no time and the once red colored star got dim and lost its reddish shawl. On the other hand, Sirius A gained mass and became the brightest star.

Assuming Conservation of mass in the Sirius system, with no planetary nebula ejection and low stellar wind. Then

The total mass before mass transfer = total mass after mass transfer.

= MA + MB

= 2.02 + 0.978 = 2.998 $M_\odot$

Since Ptolemy described Sirius (140 AD) as firry red, then we can assume then that it was in its summit as a red giant of mass about 2 $M_\odot$.

It seems that Sirius B finally collapsed on the night the prophet Mohammed ascended to heaven as the ascension was mentioned in Chapter the star that starts with the following verses:

“By the star as it collapsed (1) Your Companion is neither astray nor being misled (2) Nor does he say (aught) of (his own) Desire (3). It is no less than inspiration sent down to him (4)

That He did create in pairs, male and female(45) From a seed when lodged **(46)* That He hath promised a Second Creation (47) That it is He Who giveth wealth and satisfaction (48) That He is the Lord of Sirius (49)****

(*46=the number of chromosomes in mankind. 49 is nearly rotation period of Sirius B around Sirius A**)

The ascension was about one year before Higra, i.e about 620 AD. This in agreement with seeing Sirius as red 1400 years ago in Europe (Schlosser and Bergman, 1985).

Thus between 140 AD and 620 AD (480 years) one mass of the sun has transferred from the red giant Sirius B to Sirius A.

Thus the rate of mass transfer = 0.0021 $M_{\odot}$/year.

2-MORE ON THE ALGOL PARADOX

Although the component of Algol A (3.59 $M_{\odot}$ and B (0.79 $M_{\odot}$) formed at the same time and massive stars evolve faster than low mass star, it is observed that Algol A is still in the main sequence while Algol B is a subgiant. This paradox was solved by mass transfer.

It was thought to have started in:

Stage 1: A detached binary where Algol A was of a solar mass star while Algol B was a massive blue star.

Stage 2: As the red-giant Algol B star entered its red-giant phase, it expanded to the point where mass transfer occurred.

Stage 3: Eventually, enough mass accreted onto the smaller star Algol A that it became a blue star, leaving the other star Algol B as a red subgiant.

The New point in this research is that Ptolemy saw Algol as a white star (during stage 1) while Al Sufi in the tenth century reported it as a red star (stage 2). Now we see Algol as a white star.

So Ptolemy (140 AD) saw Algol B as a massive bright star, in less than one thousand years Al Sufi (903-986 AD) saw Algol B as a red giant. Now after 1000 years, we see Algol A a white star.

These historical observations are quite important as we can estimate the rate of mass transfer from the red Giant Algol B 1000 years to Algol A. On the assumption of conservation of the total mass of Algol A and B and ignoring any involvement from Algol C,

At present MA+ MB = 3.59 + 0.79 = 4.38 $M_{\odot}$

Assuming MA = 1 $M_{\odot}$ at the Time of Ptolemy 140 AD

Then MB = 3.38 $M_{\odot}$

At the time of Al Sufi, Algol B turned into a red giant and filled the Roche lobe, thus mass transfer started then from MB to MA

The difference of masses of MB at El Suffi time (940 AD) and at present

= 3.38-0.79= 2.59 $M_{\odot}$ transferred in 1070 years (2010-940).

Thus the rate of mass transfer from Algol B to Algol A= 0.0024 $M_{\odot}$ / year

then roughly speaking about 2.59 $M_{\odot}$ was transferred from Algol B to Algol A in about 1070 years.

Thus the rate of transfer of mass is 0.0024 $M_{\odot}$/ year.

The other point is that Algol B was on the brink from changing from a massive blue white star on 140 AD into a massive red giant about 800 years later. The third point is that the present distant between Algol A and B is 0.05 AU. We have to keep an eye on this binary system, we may see them in a short time merging into a blue straggler. Another possibility is that Algol B may turn into a white dwarf following the swallow of its outer layers by Algol A.

CONCLUSION

The Red Sirius paradox can be explained in terms of the binary system where Sirius B was seen at antiquity as red and sometimes as white due to pulsation or perhaps eclipsing effects. However as it was tabulated by Ptolemy 140 AD as fiery red it must have been it its final stage as a red giant and filled the Roche lobe. 1400 years ago it was observed red in Europe and it finally ended up as a white dwarf around 620 AD.

Joss et al. (1987) indicates that the loss of the giant envelope by Sirius B about 1400 years ago via critical lobe overflow, rather than by stellar wind or the ejection of a planetary nebula shell, may remove some of the theoretical obstacles to an extremely to an extremely rapid transition of Sirius B from a red giant to a degenerate white dwarf.

The rate of mass transfer from the red giant Sirius B to Sirius A is estimated to be 0.0021 $M_{\odot}$/yr in excellent agreement with our estimate of mass transfer from Algol B to Algol A since the time of Al Sufi who reported Algol as a red star to the present time. Assuming 2.59 $M_{\odot}$ of the Mass of Algol B to have been transferred to Algol A. during about 1070 years, then the average rate of mass transfer is 0.0024 $M_{\odot}$/yr. The dying star Algol B is only separated by 0.05 AU from Algol A. These stars might merge into a blue straggler.

We think that our estimate are good as they are observational ones.

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