Regarding the Sirius B Incident

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Introduction

This is a brief account of the events following the Disappearance of Sirius B. I trust that most readers will already be familiar with the historical context and social consequences of said events. For further insight into the topic, I recommend studying *An insight into the changes introduced by Sirius B[1]*, an exemplary work gathering all major developments following the incident. With that said, I will refrain from discussing the social components of the problem too much, only grazing over them when strictly necessary, and will strictly discuss the incident from the scientific community's point of view.

1 The Disappearance

Mainly due to a voracious sensationalist press following the event, swiftly jumping on a topic otherwise purely academic, the sudden lack of light coming from Sirius B was mistakenly first approached as a "disappearance". The term was quickly adopted by most non-academic circles for its apparently simple explanation of a very complex phenomenon, and later on, by the researchers in charge of investigating the Disappearance itself. In actuality, although Earth ceased receiving light from Sirius B, the star itself was still very much in its place, as we will see further on.

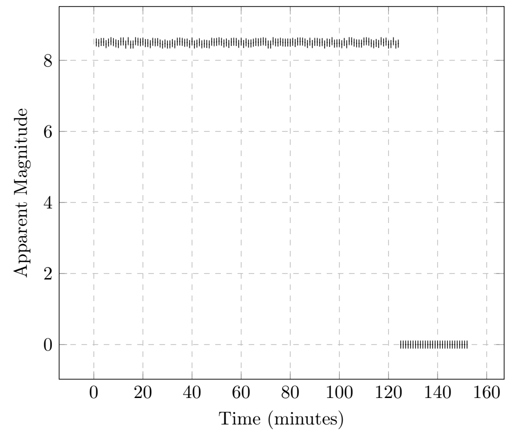

Figure 1: Data from the Disappearance measured by the Hobby–Eberly Telescope (HET) in September 19th of 2057[2].

	Sirius A	Sirius B
Evolutionary stage	Main Sequence	White Dwarf
Spectral type	A0mA1 Va	DA2
Distance	2.64 ± 0.01 pc	2.670 ± 0.002 pc
Absolute magnitude	+1.43	+11.18
Mass	$2.063 \pm 0.023 M_\odot$	$1.018 \pm 0.011 M_\odot$
Radius	$1.711 R_\odot$	$0.0084 \pm 3\% R_\odot$
Surface gravity (log)	4.33 cgs	8.57 cgs
Temperature	9,940 K	25,000 ± 200 K

Table 1: Some quick facts about the Sirius system.

After corroborating with his fellow astronomers that the data collected was indeed from the telescope, and that all systems were operational and well calibrated, Dr. Motesfont got to work, and by the next day the entire world knew of the whole ordeal. The press gave it relatively little notice at first, only including a report or two during the first day. Meanwhile, the internet went wild with ideas regarding the nature of the Disappearance, fueled by the fresh and joyful interest of young people interested in science, capable of grasping the importance of the discovery. After 24 hours, the news services caught wind of the fervor the event had caused, and quickly corrected their initial disinterest, coining soon after the famous term "the Disappearance".

The problem was first tackled by Dr. Nicola Motesfont, in charge of the Hobby–Eberly Telescope (HET)[1], in September 19th of 2057. In several interviews the now world-famous researcher has confessed that his first thought was that a joke was being played on him by his colleagues. Dr. Motesfont and his team were attempting to detect exoplanets in the vicinity of the Sirius system. The first data flowing in from the telescope showed the familiar steady line of Sirius B's apparent magnitude, followed by a sudden drop to nothing. It is universally regarded as an overwhelmingly anticlimactic proof of probably the most important astronomical event in human History.

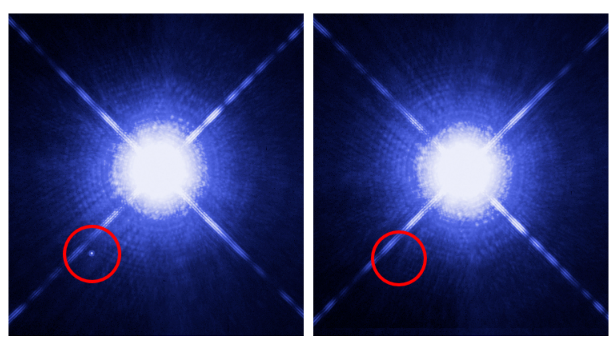

Figure 2: Before and after snapshots of the Sirius system, taken by the Hubble space telescope in June 15th of 2034 and September 20th of 2057, respectively. Sirius B circled in red.

[1] Located in Davis Mountains, Texas

[2] The full data set is available to the public in NASA's webpage.

2 Initial approach

It goes without saying that the scientific community was in shambles following the spread of the news. The more conservative circles first labeled it an aberration, a calibration error, or simply an insult to all serious science. After a couple hours, all major professional telescopes were pointed at Sirius B, or rather at where it should have been, and concluded that the star was, indeed, gone. This gave way to all shorts of attempts at explaining the phenomenon.

One of the main ideas that took form during the first days after the event was that Sirius B had, in a literal sense, disappeared. The idea took off fueled by the excitement of the general public, longing for some kind of supernatural phenomenon untouchable by science, and misdirected by the vague and misleading terms used by the press. This train of thought branched into those who thought that the star had crossed a wormhole (which opened the far-fetched possibility of establishing an outpost with the potential of spreading Humanity all over the cosmos), and those that viewed the Disappearance as an act of God. Most scientists viewed such propositions as unscientific, lacking of any logic, and in case of the latter, stupid. All of these theories were quickly dismissed mere days after the incident, after it was confirmed by several telescopes that Sirius A continued to follow its familiar orbit around the disappeared Sirius B, unperturbed by the whole event.

The fact that the gravitational effects of Sirius B were still measurable opened way to theories which tried to explain not the lack of the star, but the lack of its visibility. Some of the propositions included interstellar gas clouds[2], black holes[3], and even planets[4]. This line of thought came to be known as occlusionism, and was fairly popular the first weeks following the event. However, it quickly lost momentum once it was clear that the Disappearance was permanent, and not a product of some temporary interference.

Some more daring branches of occlusionism proposed that the occlusion was not caused by natural phenomena. The movement would later be known as artificial occlusionism, and was mocked by most part of the scientific community since the very beginning. They proposed that the lack of visibility coming from Sirius B could be caused by the deployment of a Dyson sphere, or some other kind of megastructure encompassing the entire star. This, however, failed to explain the sudden nature of the Disappearance. Others proposed that Sirius B was, in fact, some sort of alien fusion reactor mistaken for a star, that was now being shut down. All of these theories were naturally dismissed by most scientists.

3 Secondary approach

Now the center of attention, all past data collected from Sirius B was scrutinized by the best minds science had to offer. Renowned figures in science such as Rhonwen Maddy, Finnja Schlim, Adeline Charbonnier, Hayley Helman and Ela Posavac tackled the problem, among many others.

All the new research being done on the topic brought forward some major discoveries. For starters, all data coming from the star seemed to be affected by a wall of noise previously dismissed as interference with the light from its much brighter companion, Sirius A. This turned out to be unlikely. Modern techniques, such as thermodynamic bezolian spectroscopy[5], were simultaneously applied to the signal by several research teams. Most notably, Hayley Helman's work revealed that the noise could not come from electromagnetic interference or interaction with an interstellar gas cloud. The noise pattern pointed at the partial occlusion of the star by some of its shedded outer layers. Because of their extreme density and metallicity, it was hard for the community to accept that Sirius B could shed, something common in giant stars with low surface gravity, but unheard of in white dwarfs.

Once the unique nature of Sirius B was established, all previously known facts about the star were put to the test. The first of these facts to fail the unrelenting attacks of modern astrophysics was its metallicity. After being recalculated with the latest technology, and taking into account the noise introduced by its shedded outer layers, it was estimated at a much higher value than previously thought possible. White dwarfs are the result of the death of a star, which after shedding away its outer layers, leaves the core exposed. Depending on the mass of said star, the composition of the resulting remnant can vary from hydrogen and helium for the less massive stars (He-WD) to oxygen, neon and magnesium for the heavier ones (ONeMg-WD). It is generally agreed that Sirius B was the remnant of a 5 $M_\odot$ blue giant star. According to our most precise models, such a star would result in a carbon and oxygen white dwarf, a middle point between the two types previously mentioned. However, Sirius B was measured to have had extreme metallicity, with considerable amounts of silicon and iron being detected.

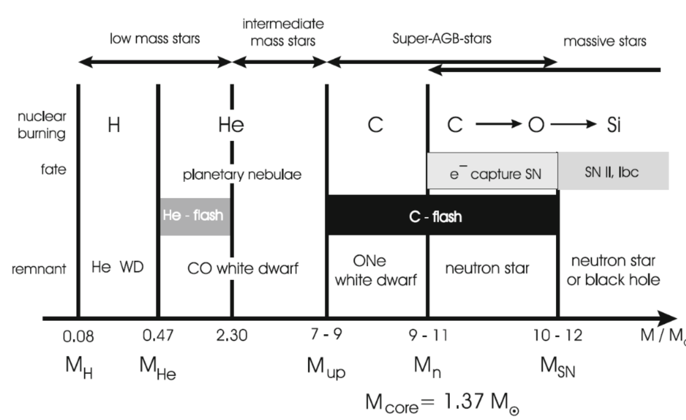

Figure 3: Transition masses between different evolutionary paths for stars, and their final fate. $M_{\rm H}, M_{\rm He}, M_{\rm up}, M_{\rm n}$, and $M_{\rm SN}$ correspond to the minimum initial stellar mass for hydrogen, helium, and carbon ignition, the formation of a neutron star, and for stars undergoing a type II supernova explosion. (After Siess 2006b)

White dwarf models still relied on Chandrasekhar's theory at the time, which assumed that the pressure inside the star was produced exclusively by the ideal (non-interacting) degenerate electrons, while the non-degenerate ions provided the mass. This was fine and dandy in most cases, but caused problems at large densities or low temperatures. Both these cases gave way to 2 of the most important theories regarding the nature of the Disappearance.

3.1 Black hole collapse theories

We will first consider the upper range of white dwarfs. This concerns the very massive white dwarfs, closely approaching the Chandrasekhar limit. Sirius B, despite not being that massive, was thought to have an abnormally large density (owing to its metallicity). There are 2 phenomena which concern us: inverse β decay and pycnonuclear reactions.

An inverse β decay consists in the capture of an electron by a proton, resulting in a neutron. If the electron cannot be reemitted back due to the Fermi energy of the degenerate matter around it being higher than that of its new, the chemical composition of the star can be gradually changed.

On the other hand, although negligible for the most part, pycnonuclear reactions may have an important role in the evolution of dense white dwarfs too. Pycnonuclear reactions defer from regular thermonuclear relations in that instead of being dependent of temperature, they depend on density. The extreme density inside white dwarfs permits them to take place at considerable rates.

Researchers like Jason O'Gormley[6] and his team proposed that a build up of heavy elements inside Sirius B, produced by pycnonuclear reactions and inverse β decays, could have caused Sirius B to surpass the Chandrasekhar limit. This would, in normal conditions, induce a supernova type Ia. However, O'Gormley proposed that the atypical high density and low mass could have instead made the star collapse on itself, creating a black hole that would have devoured the outer layers before any light could have gone out.

This theory explained the sudden nature of the event, as well as the present gravitational effects proceeding it. However, no way of testing the theory was discovered. Checking for the distortion a black hole would cause in light of stars behind it proved too difficult, mainly because the high luminosity of Sirius A made it almost impossible to see any stars at all. Many mechanisms were proposed as candidates for the formation of black holes in low mass and dense white dwarfs (most notably, the Loken-Pélissier mechanism[7], named after its discoverers), but most were painfully incomplete at best, and lacked any real predictive power.

3.2 Fast black dwarf theories

The second possibility considered by researchers at the time was a sudden cooling of Sirius B. This would also introduce disagreements between the Chandrasekhar model and reality. As in the last case, pycnonuclear reactions and inverse β decays can also occur noticeably in very cool stars. However, instead of increasing its metallicity as a means of exceeding the Chandrasekhar limit, fast black dwarf theories focused on explaining possible mechanisms for the star to crystallize violently.

Crystallization was included in stellar models even in the times of Stephen Hawking. As a result of coulomb forces between atoms, the electron gas begins to form a rigid lattice when temperatures are too cool. This steadily minimizes their total energy to a point when they stop emitting light altogether. This is known as the black dwarf stage. At the beginning of the 21st Century, detailed models of crystallization were already in use, which portrayed the general picture that it was a painfully slow process. The star would cautiously cool off via radiation and neutrino losses, and atoms would pile up at the core as a result of increasingly dominant electrostatic forces. This would not only change the star's internal arrangement, but also its chemical composition.

However, these models could not explain the rapid nature of the Disappearance. Researchers tried to think of new crystallization models that took into account extreme core metallicity and shell shedding, hoping it would result in faster processes. Most efforts were to no avail. The closest approach was made by Chase Duncan[8], who got the count down from 10^{10} years to 10^{8}.

Although extremely promising, fast black dwarf theories were unsuccessful in its attempts at developing valid mathematical models of fast crystallization. A fast mechanism for white dwarfs to cool would result in countless, minuscule, pitch-black objects with the mass of a star scattered around galaxies. In other words, massive astrophysical compact halo objects (MACHO), a perfect candidate for dark matter.

4 Expeditions to Sirius

Most of the world's space agencies began planning expeditions to Sirius B only days after the event. Most of them are still functional to this day, with replacements already on their way. They can be divided into fast probes and slow probes.

4.1 Fast probes

NASA and ESA were the first agencies to get on the race. The mission was famously labeled Serious Bee Hive Mission, and consisted of swarms of small unmanned probes equipped with 1-meter radius solar sails, and propelled by the Really Big Laser (RBL). They reused most of the technology they had already developed to launch the original Bee Hive Missions, targeted to Proxima Centauri, Alfa Centauri and Vega from 2043 to 2053. The most important element of the missions, the RBL, consisted of a partially mobile, motorized parabolic dish carved into the surface of the Moon, capable of focalizing 64 extremely energetic lasers into one single coherent beam. The RBL, probably the most iconic NASA project, could be used as a radio telescope, communication array, and, most notably, propulsion method for solar sails.

By 2063, a swarm of 1024 "bees" had been manufactured with the goal of approaching Sirius B as much as possible. Different Bees were designed for different tasks, as the small crafts could not hold too many measuring devices at once. A quarter of the swarm was equipped with magnetometers, another quarter with gravitational sensors, another quarter with energetic particle detectors, and the remaining quarter with different types of cameras (radio, infrared, visible and ultraviolet sensors). The mission ran into some financing problems, but was finally launched in 2065, scheduled to arrive to Sirius B in 2105. The data from the probes would then reach Earth by the year 2113.

Of the 1024 Bees, only 10 arrived operational. 198 of them were destroyed at launch, 782 were destroyed during flight (mainly due to micrometeors and/or interstellar space dust erosion), and 38 of them went off course. Simulations expected at least 25 probes to survive, but otherwise it was a success. After the data reached Earth, scientists were quick to discover that both the gravitational measurements and the snapshots of Sirius B confirmed that the star was indeed still there, that it was not a black hole, and that it was extremely small. Most of the imagery taken was worthless, and only 2 instance of Sirius B blocking the light of a star in the background were captured.

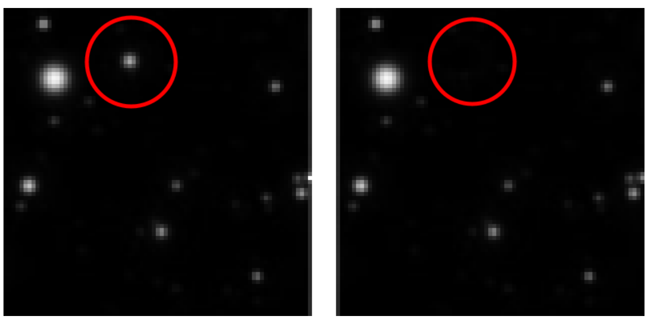

Figure 4: Occlusion of HD 100655 by Sirius B, captured by Bee 0253, 5th of December of 2105.

The most important discovery made was that no spectrometry could be done, as the star emitted no measurable light at all. With no Hawking radiation measured, no background distortion detected, and no Lense-Thirring effect recorded, black hole collapse theories received a heavy blow, and were abandoned almost completely. Fast black dwarf theories, on the other hand, received renewed attention, even though no breakthrough would be made until the data from the next missions came in.

4.2 Slow probes

Some consider the fast probe expeditions to have been a waste of taxpayer money. It is true that they only provided very limited information compared to the slower probes launched after them, only for a time gain of around 61 years. At least, it may seem like that from our point of view, now that the issue is resolved, but at the time it served as a way of motivating future generations to continue research on the topic.

The most important slow probes launched were the Dragon and Hyperion missions. Dragon missions, manufactured by the China Aerospace Science and Technology Corporation (CASC), began development soon after the deployment of the Serious Bee Hive, around 2066. They saw completion in 2072. The Dragon 5 was launched in 2073, bound to Sirius B. Their extraordinarily rapid development was due to the fact that the CASC was already well on its way to completing a similar expedition, originally targeted to Proxima Centauri. After some adjustments, most of its technology was suited for the change of course.

The Hyperion missions were manufactured by Roscosmos, and launched mere months after the Dragon 5. Roscosmos used very similar technology to that of the Dragon missions. This was no coincidence, as China and Russia planned both programs as a collaboration project. The probes consisted of a large reinforced propeller, designed to safely contain up to 6 nuclear detonations; the central bulk, containing most of the sensitive measuring devices carried by the probe; and a 2 meter thick nanofiber armor, which offered the required protection from collisions with dust and meteors encountered in interstellar travel.

The probes were put in orbit from the moon, and launched with the aid of space tugs. Once in position, the probes detonated 3 of the 6 plutonium pellets in the span of 1 year, allowing the propeller to cool off between explosions. This enabled the probes to reach 9.57% of the speed of light. Once inside Sirius B's sphere of influence, they detonated again the remaining 3 pellets, and put themselves in orbit as close as possible.

They reached Sirius B in 2164, and correctly positioned themselves in orbit in the year 2166. The Dragon 5 was equipped with cutting-edge spectroscopic technology, but was unable to detect the composition of the star due to the lack of light coming from the star. This had already been considered as a possibility by chinese engineers, so the probe had been equipped with 5 projectiles capable of piercing the outer layers of a cold star. These projectiles contained small spectroscopes capable of analyzing the composition of the star at tremendous speeds. Their speed allowed them to send their results before being destroyed by the collision.

Spectroscopic analysis showed that Sirius B had turned into an enormous, homogeneous, metal-rich crystal. The data sent by Dragon 5 reached Earth in 2174, and allowed scientists to perfect their crystallization models. Fast black dwarf theories regained huge popularity, now backed by evidence. The data showed that Sirius B's possessed an extremely exotic composition, containing traces of lanthanides, actinides, and even some previously undiscovered superactinides. Nuclear physicists were left baffled, as some of these elements needed extremely unlikely reactions to occur for them to be formed in such quantities. However, the inclusion of these new elements in crystallization models allowed a sudden chain reaction which, together with the extreme density, gravitational attraction, and metallicity, generated extremely energetic bonds to form between atoms. This process is known nowadays as the Behrmann-Wentzel mechanism[9], and successfully predicts the way such a process would occur.

Their work also showed that the sudden crystallization seen in Sirius B was actually a periodic catatonic state white dwarfs with similar compositions would regularly fall into given the right conditions. Said white dwarfs would then oscillate between active and crystallized states at regular intervals of approximately 5000 years.

With that out of the way, scientists had left to explain the formation of such heavy elements inside a white dwarf, and the reason behind Sirius B's shedded outer layers. Both this problems were resolved by the data sent by Hyperion 3, Dragon 5's russian companion. Hyperion 3 was equipped with high-fidelity, full-spectrum electromagnetic sensors, capable of detecting planets and satellites at great distances. In 2179, Hyperion 3 sent to Earth the image of what seemed an artificial industrial complex, the size of our Moon, orbiting Sirius B at a distance of 0.1 AU.

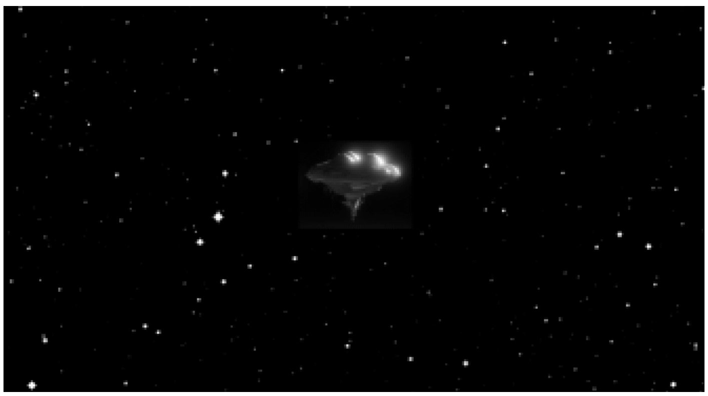

Figure 5: Image of the alien industrial complex orbiting Sirius B, taken by Hyperion 3, 25th of March of 2179.

5 Conclusion

Most of the scientific community nowadays believes that the industrial complex around Sirius B is the megastructure equivalent of a mining rig, and is responsible for the rare elements present inside the star. It is thought that these were introduced by the builders of the rig as catalysts, in order to induce a crystallized state, which would allow for safe mining operation on the surface. Said operations would also explain the dust that contaminated spectroscopic data on Earth, in orbit around the star as a result of mining efforts. Despite our efforts, no contact has yet been made with alien life. Said efforts include sending highly localized laser massages with the Really Big Laser, Bee Hive missions to most of our closer stars, and omnidirectional broadcast of radio waves from space stations.

As I am writing this article, several missions with the goal of docking with the mining rig are being planned. Until they arrive at the site, there is no way of knowing if we missed the constructors by a couple thousand years, coinciding with the last crystallization stage of Sirius B, or by eons. In 2185, Procyon B disappeared from the sky, suggesting that the constructors of the mining rig built other sites all over this part of the galaxy. If there is a way for us to learn from their technology, and possibly even use it, remains to be seen.

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