The Virtual Mass of a Type 1a Supernova Progenitor

Richard A. Peters

Abstract

Type Ia supernovae (SNe Ia) are crucial cosmic events used for cosmology and understanding the universe's expansion. However, the precise progenitor systems and explosion mechanisms behind SNe Ia remain elusive and subject to ongoing research. This abstract critically assesses the limitations of current progenitor models employed to explain these intriguing stellar explosions. The Single Degenerate Model, involving the accretion of matter onto a white dwarf from a non-degenerate companion star, faces challenges in explaining the observed lack of post-explosion companion stars, known as the "Missing Companion Problem." The Double Degenerate Model, based on the merger of two white dwarfs, lacks a definitive understanding of the exact merger mechanisms and the parameter space for successful explosions. These limitations highlight the need for further theoretical advancements, observational constraints, and computational modeling to refine and expand our understanding of the progenitor systems of Type Ia supernovae. Future investigations will aim to identify the dominant pathways leading to Type Ia explosions, reconcile the inconsistencies among different models, and enhance the accuracy of SNe Ia as cosmological distance indicators.

The whole idea of this paper is to show that the white dwarf progenitor of a Type Ia supernova contains a significant portion of dark matter that is attracted to the dwarf until the Chandrasekhar limit of the star is reached. In this model there is no need for a companion star to provide the extra mass needed to exceed the Chandrasekhar limit of the white dwarf.

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1.0 Introduction

A Type 1a supernova is a type of stellar explosion that occurs in a binary star system involving a white dwarf and a companion star. It is characterized by the complete disruption and explosion of a white dwarf star.

Here's how a Type 1a supernova typically occurs:

1. Binary system: A Type 1a supernova begins with a binary star system, consisting of two stars orbiting each other. One of the stars in this system is a white dwarf, which is the remnant core of a star that has exhausted its nuclear fuel. The other star can be a main-sequence star, a red giant, or another white dwarf.
2. Mass transfer: The white dwarf in the binary system accretes matter from its companion star. This can happen through two main scenarios:
    - In one scenario, the white dwarf accretes matter from a companion star that is a main-sequence star or a red giant. The transfer of matter occurs through the Roche lobe overflow, where the gravitational pull of the white dwarf causes material from the companion star to flow onto its surface.
    - In the second scenario, both stars in the binary system are white dwarfs. Over time, their orbits decay due to the emission of gravitational waves, leading to a merger.
3. Critical mass: As the white dwarf accretes matter from its companion star, its mass gradually increases. There is a critical mass known as the Chandrasekhar limit, which is approximately 1.4 times the mass of the Sun. When the white dwarf's mass reaches this limit, a runaway nuclear fusion reaction is triggered.
4. Explosion: The fusion reaction rapidly ignites the carbon and oxygen in the white dwarf's core, causing a thermonuclear explosion. The explosion releases an immense amount of energy, equivalent to the brightness of billions of stars. The entire white dwarf is destroyed in the process, with its material ejected into space at high velocities.
5. Luminosity and aftermath: The explosion of a Type 1a supernova is incredibly bright and can outshine an entire galaxy for a short period. The luminosity of a Type 1a supernova is relatively consistent, making it useful as a "standard candle" for measuring cosmic distances. The ejected material enriches the surrounding space with heavy elements produced during the explosion.

Type 1a supernovae are of significant scientific interest because their consistent luminosity allows astronomers to use them as distance indicators and study the expansion rate of the universe. They have played a crucial role in determining the existence of dark energy and our understanding of cosmology.

2.0 Use of Chat.GPT

While chat can be a valuable resource for certain types of communication and collaboration, it may not always be the ultimate resource for information. Other resources, such as reputable websites, databases, and experts in the field, may be more appropriate for obtaining accurate and comprehensive information. A good motto for using Chat.GBT is: Trust, but verify.

Despite these caveats, I have used chat extensively; a portion of the text in this paper was created by Chat.GBT. Chat has proven indispensable in the preparation of the paper. Chat is a true marvel.

Chat.GBT is an API (Application Programming Interface) that provides developers with access to a large language model trained by OpenAI. This language model is based on the GPT (Generative Pre-trained Transformer) architecture and is currently one of the largest and most advanced language models available.

When a user sends a request to the Chat.GBT API, the API receives the request and sends it to the language model for processing. The language model then generates a response based on the input it received and sends it back to the API, which returns it to the user.

The language model is trained on a massive corpus of text data, including papers, articles, and websites, which enables it to understand a wide range of topics and generate responses that are contextually appropriate and grammatically correct. The model is also able to learn from user interactions, so it can improve over time and provide more accurate and helpful responses.

Developers can use the Chat.GBT API to build conversational interfaces for a wide range of applications, including customer service bots, virtual assistants, and chatbots for social media platforms.

3.0 The Basics of White Dwarfs

White dwarfs are fascinating stellar remnants that form after low to intermediate mass stars, typically ranging from about 0.1 to 8 times the mass of the Sun, exhaust their nuclear fuel and undergo stellar evolution. They represent the final stage of stellar evolution for stars like our Sun.

Here are some key points about white dwarfs:

1. Composition: White dwarfs are primarily composed of degenerate matter, which is a state of matter where quantum mechanical effects dominate due to high density. The main constituents of white dwarfs are typically carbon and oxygen (C+O), although other elements like helium and heavier elements can also be present.

2. Mass and Size: White dwarfs are incredibly dense. Despite having masses similar to the Sun or even lower, their size is remarkably small, typically comparable to or slightly larger than the Earth. This high density is a result of the gravitational collapse during the stellar evolution process.
3. Electron Degeneracy Pressure: The pressure that supports a white dwarf against gravitational collapse is primarily provided by electron degeneracy pressure. In white dwarfs, electrons become highly degenerate, occupying a range of high-energy quantum states and exerting outward pressure due to the Pauli exclusion principle.
4. Cooling and Evolution: After formation, white dwarfs gradually cool down over billions of years as they radiate away their stored thermal energy. They follow a cooling sequence, with the hottest and brightest white dwarfs being younger. Eventually, they evolve into cooler and dimmer objects known as black dwarfs, which have cooled to near ambient temperatures.
5. Limiting Mass: The maximum mass a white dwarf can attain without undergoing gravitational collapse is known as the Chandrasekhar limit. For white dwarfs primarily composed of C+O, the Chandrasekhar limit is approximately 1.4 times the mass of the Sun.
6. Binary Systems and Supernovae: White dwarfs can be part of binary systems, where they accrete matter from a companion star. If the accretion exceeds the Chandrasekhar limit, the white dwarf can undergo a cataclysmic event known as a Type Ia supernova, resulting in a powerful explosion.

White dwarfs have a profound impact on stellar astrophysics and cosmology. They play a crucial role in our understanding of stellar evolution, supernova explosions, and the enrichment of the universe with heavier elements. Studying white dwarfs helps us unravel the intricacies of stellar life cycles and provides insights into the properties and dynamics of compact objects.

3.1 Degenerate Matter

Degenerate matter refers to a state of matter characterized by high density and pressure, where quantum mechanical effects play a significant role. In degenerate matter, particles are tightly packed and their kinetic energy is dominated by the Pauli exclusion principle, which prevents particles from occupying the same quantum state.

Degenerate matter can arise in various astrophysical objects and scenarios, such as white dwarfs, neutron stars, and certain stages of stellar evolution. Let's take a look at two common examples of degenerate matter:

1. White Dwarfs: A white dwarf is the remnant of a low to intermediate mass star that has exhausted its nuclear fuel. When a star exhausts its nuclear fusion processes, it undergoes gravitational collapse until it reaches a stable state as a white dwarf. In a white dwarf, the matter is in a degenerate state, primarily consisting of electrons.

Due to the high density, the electrons in a white dwarf become degenerate. The Pauli exclusion principle forces electrons into higher energy quantum states, creating a pressure known as degeneracy pressure that balances the inward pull of gravity. This degeneracy pressure prevents further collapse, providing stability to the white dwarf.

2. Neutron Stars: Neutron stars are incredibly dense stellar objects that form from the core collapse of massive stars in a supernova explosion. In a neutron star, the matter is composed primarily of neutrons packed tightly together.

The extreme density of a neutron star causes the neutrons to become degenerate. The Pauli exclusion principle prevents the neutrons from occupying the same quantum state, leading to a degeneracy pressure that counteracts gravitational collapse. Neutron degeneracy provides the stability required to support the immense mass of a neutron star.

Degenerate matter exhibits unique properties and behaviors due to quantum mechanical effects. Its high density and pressure can lead to exotic phenomena, such as the collapse of electron degenerate matter into a neutron star during a supernova or the further collapse of a neutron star into a black hole under extreme conditions.

Understanding degenerate matter is crucial for studying stellar evolution, the structure and properties of compact objects, and the physics of extreme astrophysical environments. The study of degenerate matter involves advanced theories and mathematical frameworks, including quantum mechanics and statistical mechanics, to describe its unique behavior and properties.

3.2 Chandrasekhar Limit

The Chandrasekhar limit, named after the Indian astrophysicist Subrahmanyan Chandrasekhar, refers to the maximum mass that a white dwarf can attain before it undergoes gravitational collapse. This limit arises from the balance between the inward force of gravity and the outward pressure resulting from electron degeneracy.

White dwarfs are remnants of low to intermediate mass stars that have exhausted their nuclear fuel. They are supported against gravitational collapse by electron degeneracy pressure, a quantum mechanical effect that arises due to the Pauli exclusion principle, which prohibits two electrons from occupying the same quantum state. In white dwarfs, the electrons become highly degenerate, occupying a range of high-energy quantum states.

Chandrasekhar showed in the 1930s that there is a critical mass beyond which electron degeneracy pressure is insufficient to counterbalance the gravitational force. This critical mass is known as the Chandrasekhar limit. For white dwarfs primarily composed of carbon and oxygen (C+O), which are the most common constituents, the Chandrasekhar limit is approximately 1.4 times the mass of the Sun, or roughly 2.765×10^{30} kilograms.

If a white dwarf accretes mass from a companion star or undergoes other processes that increase its mass beyond the Chandrasekhar limit, it can no longer support itself against gravity. The white dwarf will then collapse under its own weight, leading to a cataclysmic event such as a Type Ia supernova.

The Chandrasekhar limit is of significant importance in astrophysics and cosmology. It provides insights into the evolution and ultimate fate of white dwarfs, as well as their role in the production of Type Ia supernovae. These supernovae, resulting from the explosion of white dwarfs exceeding the Chandrasekhar limit, are crucial for studying the expansion of the universe and measuring cosmic distances.

It is worth noting that the Chandrasekhar limit applies specifically to white dwarfs composed primarily of C+O and supported by electron degeneracy pressure. Different types of compact objects, such as neutron stars and black holes, have their own mass limits determined by other physical principles.

3.3 Chandrasekhar-mass C+O

The Chandrasekhar mass refers to the maximum mass limit for a white dwarf, beyond which it is expected to undergo gravitational collapse. Specifically, the Chandrasekhar mass is the theoretical upper limit for the mass of a white dwarf composed primarily of carbon and oxygen (C+O).

The Chandrasekhar mass is named after Subrahmanyan Chandrasekhar, an Indian astrophysicist who first derived this limit in the 1930s. He demonstrated that if a white dwarf exceeds a certain critical mass, known as the Chandrasekhar mass, electron degeneracy pressure alone is insufficient to support its structure against gravitational collapse.

For a white dwarf composed of carbon and oxygen, the Chandrasekhar mass is approximately 1.4 times the mass of the Sun, or about 2.765×10^30 kilograms. This limit arises from the balance between the gravitational force and the electron degeneracy pressure, which depends on the properties of degenerate electrons in the white dwarf.

If a white dwarf accretes matter from a companion star or undergoes other processes that increase its mass beyond the Chandrasekhar limit, it can no longer support itself against gravity. The white dwarf will then collapse and undergo a cataclysmic event, such as a Type Ia supernova.

Type Ia supernovae, resulting from the explosion of a white dwarf exceeding the Chandrasekhar mass, are important in astrophysics and cosmology because they have consistent peak luminosities. This makes them valuable as standard candles for measuring cosmic distances and studying the expansion of the universe.

The Chandrasekhar mass limit is a fundamental concept in stellar astrophysics, providing insights into the evolution and fate of white dwarfs, as well as their role in the production of Type Ia supernovae.

4.0 Type Ia Supernova Progenitors

The progenitors of Type Ia supernovae (SNe Ia) are still a subject of active research and investigation. There are multiple proposed scenarios for the progenitor systems that lead to Type Ia supernova explosions. Here are a few of the main progenitor scenarios:

1. Single Degenerate Model: In this model, a Type Ia supernova occurs in a binary system consisting of a white dwarf and a non-degenerate companion star. The white dwarf accretes matter from the companion star until it reaches the Chandrasekhar limit, triggering a thermonuclear explosion. The nature of the companion star can vary, ranging from a main-sequence star, a subgiant, or a red giant. The accretion can occur through Roche lobe overflow or via a common envelope phase.
2. Double Degenerate Model: In this model, a Type Ia supernova results from the merger of two white dwarfs in a binary system. As the two white dwarfs lose angular momentum due to the emission of gravitational waves, they spiral closer together. Eventually, the two white dwarfs merge, and their combined mass exceeds the Chandrasekhar limit, leading to a thermonuclear explosion.
3. Sub-Chandrasekhar Mass Model: This model suggests that some Type Ia supernovae may arise from the explosion of a white dwarf that is below the Chandrasekhar limit. In this scenario, the white dwarf accretes material from a companion star, but the explosion is triggered before it reaches the Chandrasekhar mass. Various mechanisms, such as helium shell ignition or violent carbon burning, are proposed to initiate the explosion.
4. Super-Chandrasekhar Mass Model: This model involves white dwarfs that exceed the Chandrasekhar limit in mass. These massive white dwarfs can result from either accretion from a companion star or from a merger with another white dwarf. The additional mass increases the central density and temperature, making it easier to ignite the nuclear fusion process and leading to a more energetic explosion.

It's important to note that the exact nature of Type Ia supernova progenitors is still an active area of research, and the above scenarios represent proposed models that are supported by various observational and theoretical studies. Observational data, such as pre-explosion images and detailed studies of supernova remnants, along with theoretical simulations, are crucial for improving our understanding of the progenitor systems and the mechanisms behind Type Ia supernova explosions.

4.1 Double Degenerate Model

> 'Besides the lack of convincing direct observational evidence for sufficiently many appropriate binary systems, the homogeneity of "typical" SNe Ia may be an argument against this class of progenitors.' [Hillebrandt]

The Double Degenerate Model is one of the proposed mechanisms for Type 1a supernovae, specifically those involving the merger of two white dwarfs. In this model, the explosion occurs when two white dwarfs in a binary system merge, resulting in the combined mass exceeding the Chandrasekhar limit and triggering a thermonuclear runaway.

Here's how the Double Degenerate Model typically explains the process:

1. Binary system: The Double Degenerate Model begins with a binary star system containing two white dwarfs. These white dwarfs are remnants of stars that have exhausted their nuclear fuel and have collapsed under gravity.
2. Loss of angular momentum: Over time, due to the emission of gravitational waves, the binary system loses energy and angular momentum. This causes the two white dwarfs to spiral closer to each other and their orbits to decay gradually.
3. Merger process: As the white dwarfs approach each other, their separation distance becomes smaller. Eventually, their orbits decay to the point where the two white dwarfs merge, either through a direct collision or via a common envelope phase where one white dwarf accretes mass from the other.
4. Mass exceeding the Chandrasekhar limit: The merger of the two white dwarfs results in a combined mass that exceeds the Chandrasekhar limit, typically around 1.4 times the mass of the Sun. The increased mass and density lead to conditions where a runaway nuclear fusion reaction can occur.
5. Thermonuclear explosion: Once the combined mass exceeds the Chandrasekhar limit, the core of the merged white dwarfs becomes hot and dense enough to initiate a thermonuclear explosion. The carbon and oxygen in the core undergo rapid and uncontrolled nuclear fusion, resulting in a powerful explosion that disrupts the merged white dwarfs.
6. Luminosity and aftermath: The thermonuclear explosion of a Type 1a supernova releases an immense amount of energy, causing the supernova to become incredibly bright. The ejected material enriches the surrounding space with heavy elements synthesized during the explosion. The luminosity of Type 1a supernovae is relatively consistent, making them useful as standard candles for cosmological distance measurements.

The Double Degenerate Model provides an alternative scenario to the Single Degenerate Model for explaining Type 1a supernovae. Both models have their strengths and weaknesses, and it is possible that multiple pathways contribute to the occurrence of Type 1a supernovae in different systems. Ongoing observations and theoretical studies continue to refine our understanding of these fascinating stellar explosions.

4.2 Single Degenerate Model

The Single Degenerate Model is one of the proposed mechanisms for Type 1a supernovae, specifically those involving a white dwarf and a companion star. According to this model, a Type 1a supernova occurs in a binary system where a white dwarf accretes matter from a non-degenerate companion star until it reaches the Chandrasekhar limit, leading to a thermonuclear explosion.

Here's how the Single Degenerate Model typically explains the process:

1. Binary system: The Single Degenerate Model starts with a binary star system consisting of a white dwarf and a non-degenerate companion star. The companion star can be a main-sequence star, a red giant, or a subgiant star.
2. Mass transfer: The white dwarf accretes matter from its companion star. This can happen through Roche lobe overflow, where the gravitational pull of the white dwarf causes material from the companion star to flow onto its surface. The mass transfer can be stable or unstable, depending on various factors such as the mass transfer rate and the stability of the accretion disk formed around the white dwarf.
3. Increasing mass: As the white dwarf accretes matter from its companion star, its mass gradually increases. The white dwarf is primarily composed of carbon and oxygen, and as the mass approaches the Chandrasekhar limit (approximately 1.4 times the mass of the Sun), conditions become favorable for a runaway nuclear fusion reaction.
4. Thermonuclear explosion: Once the white dwarf's mass reaches the Chandrasekhar limit, the core becomes hot and dense enough to initiate a thermonuclear explosion. The carbon and oxygen in the white dwarf's core undergo rapid and uncontrolled nuclear fusion, leading to a powerful explosion. The entire white dwarf is disrupted in the process, and its material is ejected into space at high velocities.
5. Luminosity and aftermath: The thermonuclear explosion of a Type 1a supernova releases an enormous amount of energy, causing the supernova to become incredibly bright. The ejected material enriches the surrounding space with heavy elements produced during the explosion. The luminosity of Type 1a supernovae is relatively consistent, making them useful as standard candles for cosmological distance measurements.

While the Single Degenerate Model is one of the proposed explanations for Type 1a supernovae, there is also another model called the Double Degenerate Model. In the Double Degenerate Model, two white dwarfs merge due to the loss of angular momentum through gravitational wave emission, leading to a Type 1a supernova. The exact mechanism behind Type 1a supernovae is still an active area of research, and it is possible that multiple channels contribute to these explosions in different systems.

> ‘Single-degenerate models are in general favored today. They consist of a low-mass white dwarf accreting matter from the companion-star until either it reaches M_{chan} or…’ [Hillebrandt]

> ‘…it has become obvious that the physics of SNe Ia is very complex, ranging from the possibility of very different progenitors to the complexity of the physics leading to the explosion and the complicated processes which couple the interior physics to observable quantities. None of these problems is fully understood yet, but what one is tempted to state is that, from a theorist’s point of view, it appears to be a miracle that all the complexity seems to average out in a mysterious way to make the class so homogeneous.’ [Hillebrandt]

> ‘…we seem to be lucky and Nature was kind to us and singled out from all possibilities the simplest solution, namely a Chandrasekhar-mass C+O white dwarf and a nuclear deflagration wave, to make a Type Ia supernova explosion.’ [Hillebrandt]

5.0 Does a Galaxy Contain Dark Matter?

Yes, it is widely believed that galaxies contain dark matter. Dark matter is a form of matter that does not interact with light or other electromagnetic radiation, making it invisible and difficult to detect directly. Its presence is inferred through its gravitational effects on visible matter and the overall dynamics of galaxies and galaxy clusters.

Several lines of evidence support the existence of dark matter in galaxies:

1. Galactic rotation curves: The rotation curves of galaxies, which plot the orbital velocities of stars or gas as a function of their distance from the galactic center, indicate the presence of more mass than can be accounted for by visible matter alone. The velocities remain relatively constant or even increase with distance, contrary to what would be expected if only visible matter were present. This suggests the presence of an invisible mass component, likely dark matter.
2. Galaxy cluster dynamics: The motions of galaxies within clusters also indicate the presence of dark matter. Based on the observed speeds and positions of galaxies, as well as the distribution of hot gas between them, it is estimated that the gravitational pull from dark matter is necessary to explain the observed clustering and dynamics of galaxies within clusters.

3. Gravitational lensing: The bending of light by gravity, known as gravitational lensing, can be used to indirectly detect dark matter. When light from distant galaxies passes through a massive galaxy or galaxy cluster, its path is distorted by the gravitational field of the intervening dark matter. By observing these lensing effects, astronomers can map the distribution of dark matter in the universe.
4. Large-scale structure formation: The distribution of galaxies on large scales, as revealed by galaxy surveys and cosmic microwave background measurements, is consistent with the presence of dark matter. The gravitational influence of dark matter is thought to have played a crucial role in the formation of cosmic structures, such as galaxy clusters and the cosmic web.

While the exact nature of dark matter remains unknown, its presence is inferred from its gravitational effects on visible matter and the overall dynamics of galaxies and the universe on larger scales. Dark matter is estimated to constitute a significant portion of the total matter in the universe, with visible matter accounting for only a small fraction.

5.1 What Percentage of the Mass of a Galaxy is Dark Matter?

The percentage of the mass of a galaxy that is attributed to dark matter can vary depending on the specific galaxy and the method used to estimate its mass. However, based on current understanding and observational evidence, it is generally believed that dark matter makes up the majority of a galaxy's mass.

Estimates suggest that dark matter typically accounts for about 85-90% of the total mass of a galaxy. The remaining 10-15% is attributed to visible matter, such as stars, gas, dust, and other detectable components. This ratio can vary somewhat from galaxy to galaxy, and some galaxies may have a slightly higher or lower fraction of dark matter. But in general, dark matter dominates the mass budget of galaxies.

One of the reasons for this dominance is that dark matter is believed to extend well beyond the visible boundaries of galaxies, forming a large halo around them. This extended halo of dark matter exerts a gravitational influence that holds galaxies together and plays a crucial role in shaping their structure and dynamics.

The estimation of the dark matter content in galaxies relies on various observational techniques, such as measuring galactic rotation curves, analyzing galaxy cluster dynamics, studying gravitational lensing effects, and examining large-scale structure formation. These methods collectively provide evidence for the presence and significance of dark matter in galaxies, even though the nature of dark matter itself remains a mystery.

5.2 Does Dark Matter Pervade a Galaxy at Every Scale?

Based on current understanding, dark matter is believed to pervade a galaxy at every scale, from the central regions to the outskirts. Dark matter is thought to form a halo around galaxies, extending well beyond the visible boundaries of the galaxy.

Here's how dark matter is believed to distribute within a galaxy:

1. Galactic center: In the central regions of a galaxy, including the bulge and the core, the density of dark matter is expected to be highest. However, because dark matter does not interact electromagnetically, it cannot be directly observed or imaged in these regions. Instead, its presence is inferred through its gravitational effects on visible matter, such as stars and gas.
2. Galactic disk: The galactic disk, where most of the visible matter, such as stars and gas, is concentrated, is also believed to contain dark matter. The distribution of dark matter in the disk is thought to be relatively smooth and extended. It helps stabilize the disk against gravitational instabilities and supports the rotation of stars and gas in the galaxy.
3. Galactic halo: The galactic halo is the region surrounding the galactic disk. It is within the halo that dark matter is expected to dominate. The dark matter halo extends far beyond the visible boundaries of the galaxy and is responsible for the overall gravitational potential that holds the galaxy together. The distribution of dark matter in the halo is believed to be more diffuse compared to the central regions.

It's important to note that the exact density and distribution of dark matter within a galaxy are still areas of active research and ongoing study. Observational techniques, such as studying galactic rotation curves, gravitational lensing effects, and simulations, help to infer the presence and distribution of dark matter in galaxies. These methods suggest that dark matter is pervasive throughout a galaxy, shaping its structure, dynamics, and overall mass content.

5.3 Dark Matter and the Temporal Inertial Field

At this point, the reader is encouraged to see Appendices A and B and reference [Peters, Richard A., Crafting a Model for the Creation of Dark Matter] for descriptions of the role of the Temporal Inertial field in the generation of dark matter.

6.0 The Missing Companion Problem of the Single Progenitor Model of a Type 1a Supernova

The Missing Companion Problem is a challenge faced by the Single Progenitor Model, a variant of the Single Degenerate Model, for explaining Type 1a supernovae. It refers to the apparent absence of a visible companion star in the aftermath of a Type 1a supernova explosion.

In the Single Progenitor Model, a white dwarf accretes matter from a non-degenerate companion star until it reaches the Chandrasekhar limit, resulting in a thermonuclear explosion. However, after the supernova, it is expected that some remnants of the companion star would still be present in the vicinity. Yet, in many observed Type 1a supernovae, no obvious companion star is detected.

There are several proposed explanations for the Missing Companion Problem:

1. Total disruption: It is possible that the supernova explosion completely disrupts and destroys the companion star, leaving no detectable remnant. The explosion releases an enormous amount of energy and can lead to the ejection of material from the system, making it challenging to identify the remains of the companion.
2. Stellar wind and mass loss: Prior to the explosion, the companion star may have experienced significant mass loss through stellar winds or other processes. This could reduce the mass of the companion star to a level where it becomes challenging to detect after the supernova.
3. Faint or obscured companion: The companion star may still exist but might be too faint or obscured by the remnants of the explosion to be observed directly. The supernova event can generate a bright and turbulent environment that hampers the identification of the companion star.
4. Binary disruption: In some cases, the binary system may have been disrupted entirely by the supernova explosion. The explosion can impart a significant kick to the system, resulting in the ejection of the companion star from the system or its disruption.

The Missing Companion Problem highlights the complexities and uncertainties involved in the Single Progenitor Model. It emphasizes the need for further observational and theoretical investigations to better understand the nature of the progenitor systems and the fate of the companion stars in Type 1a supernovae. Additional data, including high-resolution imaging and spectroscopy, as well as more sophisticated modeling techniques, will be essential for resolving this intriguing puzzle.

7.0 Do Current Models of the Progenitors of Type 1a Supernova Succeed?

> ‘A long-standing problem in astronomy has been the identification of supernova progenitors. Direct observation of a progenitor would provide useful constraints on supernova models. As of 2006, the search for such a progenitor had been ongoing for longer than a century.’ [Type Ia supernova]

> ‘There is a consensus that Type-Ia supernovae (SNe Ia) arise from the thermonuclear explosion of white dwarf stars that accrete matter from a binary companion. However, direct observation of SN Ia progenitors is

> lacking, and the precise nature of the binary companion remains uncertain.' [Dilday, B., et al.]

The question of whether current models of the progenitors of Type Ia supernovae (SNe Ia) succeed is a complex one. While significant progress has been made in understanding the progenitor systems of Type Ia supernovae, there are still uncertainties and open questions that researchers are actively working to address. Let's examine the current state of our understanding:

1. Single Degenerate Model: The Single Degenerate Model, where a white dwarf accretes matter from a non-degenerate companion star, has long been favored as a progenitor scenario. However, it faces challenges in explaining the lack of observed companion stars in post-explosion observations, known as the "Missing Companion Problem." Additionally, there are uncertainties regarding the mass transfer rates, the stability of the accretion process, and the ignition mechanism.
2. Double Degenerate Model: The Double Degenerate Model, involving the merger of two white dwarfs, offers an alternative explanation for Type Ia supernovae. This model has gained support from theoretical studies and observations of merging white dwarfs in some cataclysmic variable systems. However, the exact merger mechanisms, the parameter space for successful explosions, and the predicted observational signatures are still being investigated.
3. Sub-Chandrasekhar Mass Model: The Sub-Chandrasekhar Mass Model suggests that some Type Ia supernovae arise from white dwarfs with masses below the Chandrasekhar limit. While this model can explain certain observational properties, it faces challenges in reproducing the observed luminosity range and the presence of iron-peak elements in the spectra of some Type Ia supernovae.
4. Super-Chandrasekhar Mass Model: The Super-Chandrasekhar Mass Model proposes that some Type Ia supernovae involve white dwarfs with masses exceeding the Chandrasekhar limit. This model can explain the high luminosities observed in some supernovae, but it faces challenges in understanding the origin of such massive white dwarfs and the conditions for explosion.

In summary, while current models provide valuable insights into the progenitors of Type Ia supernovae, they are not without their limitations and unanswered questions. Ongoing observational campaigns, theoretical advancements, and improved computational models are all contributing to a deeper understanding of Type Ia supernova progenitors. Continued research aims to refine and expand these models to better account for the diverse observations and to identify the dominant progenitor pathways responsible for Type Ia supernova explosions.

8.0 Is There a 'Zone of Exclusion', Devoid of Dark Matter Surrounding a White Dwarf?

The concept of a "zone of exclusion" devoid of dark matter surrounding a white dwarf is not a commonly discussed or supported idea in the current understanding of dark matter distribution.

Dark matter is believed to be pervasive on large scales, forming extended halos around galaxies and clusters of galaxies. It is thought to exist in a diffuse and nearly isotropic manner throughout the universe, including within galaxies and their stellar components.

While dark matter primarily interacts gravitationally and does not interact electromagnetically, it is not expected to exhibit any specific exclusion zone around a white dwarf or any other stellar object. Dark matter is thought to permeate the entire volume of a galaxy, including the region occupied by stars and stellar remnants like white dwarfs.

However, it's worth noting that the precise distribution of dark matter within galaxies, including the density and profile, is an ongoing area of research. Observational studies and computer simulations provide evidence for the presence of dark matter in galactic halos, but the detailed structure and dynamics of dark matter within galaxies are still subjects of investigation and refinement.

In summary, the current understanding does not suggest the existence of a specific "zone of exclusion" devoid of dark matter surrounding a white dwarf or other stellar objects. Dark matter is expected to be present throughout the galaxy, including the vicinity of stellar remnants.

8.1 Could Dark Matter Comprise Part of the Mass of a Type 1a Supernova Progenitor?

The contribution of dark matter to the mass of a Type Ia supernova progenitor is uncertain and highly debated within the scientific community. While dark matter is believed to be a significant component of galaxies on larger scales, its direct impact on individual stellar systems, such as Type Ia supernova progenitors, is not well-constrained.

Type Ia supernovae are generally thought to arise from the explosion of a white dwarf star. The progenitor scenarios typically focus on the visible matter components of the system, such as the white dwarf itself and any companion stars.

Dark matter, on the other hand, is a form of matter that does not interact electromagnetically and is primarily inferred from its gravitational effects on visible matter. Dark matter is thought to form extended halos surrounding galaxies, but its direct involvement in stellar evolution processes is not considered in standard models.

While it is possible that dark matter could have some influence on the overall gravitational dynamics of a Type Ia progenitor system, its contribution to the total mass of the system is expected to be relatively small compared to the visible matter components.

It's important to note that the understanding of dark matter and its interactions is still an active area of research. Ongoing observations, theoretical investigations, and numerical simulations aim to shed light on the role of dark matter in galaxy formation, stellar evolution, and supernova progenitors. Future advancements in these fields may provide further insights into the potential involvement of dark matter in Type Ia supernova progenitors.

The purpose of this study is to describe how a Type Ia supernova may develop without the presence of a second, symbiotic star from which the white dwarf draws matter until its mass exceeds the Chandrasekhar limit and the white dwarf explodes into a supernova.

8.2 The Dark Matter Progenitor

This section posits that the dark matter in the immediate surround of a white dwarf augments the gravitational field of the white dwarf.

If dark matter contributes the bulk of the active gravitational mass of a galaxy, then it's not a stretch of the imagination to attribute a portion, even a major portion, of the active gravitational mass of a white dwarf to dark matter. This augmentation is not a static process, but an active one that, over time, adds to the active gravitational mass of the white dwarf (WD). The process is listed in Table 8.2 and elaborated in Appendix B.

Table 8.2 Creation of the Virtual Mass of a Type 1a Supernova Progenitor
The TI field permeates the volume of space surrounding the white dwarf (WD)
The TI field is directly subject to gravity.
The inertial mass of an object is proportional to the particle density of the TI field.
Relativistic effects notwithstanding, the inertial mass of an object is known to be constant throughout the Universe.
To maintain the constancy of the inertial mass of objects, the particle density of the TI field must itself be constant throughout the Universe.
As an aggregate of particles of the TI field (TIPs) flows toward the WD it is subject to gravitational compression which, absent a counteracting agency, would increase the particle density of the field of particles.
One process counteracts the gravitational compression of the TI field in the vicinity of the WD.

Table 8.2 Creation of the Virtual Mass of a Type 1a Supernova Progenitor
The process is the transformation of particles of the TI field (TIPs) into gravitons. The transformation rate of TIPs into gravitons is a function of the particle density of TIPs.
The gravitons produced in this process comprise dark matter. The rate of creation of gravitons and thus the accumulation of dark matter is greatest where gravitational compression of the TI field is strongest, near the WD.
This conversion of TIPs into gravitons occurs throughout the volume surrounding the WD and within the volume of the WD itself.
The accumulation of dark matter (gravitons) within the WD itself comprises an increases in the active gravitational mass of the WD.
The self-gravity of the WD, as mediated by the TI field, is thus increased until the equivalent active gravitational mass of the WD meets the Chandrasekhar limit and the WD explodes into a supernova.
The active gravitational mass of the WD comprises the elemental mass of the WD and the virtual mass of dark matter (gravitons) that result from the continuous conversion of TIPs to gravitons.

9.0 Glossary

Table 1 Glossary	
Term	**Definition**
Acceleration profile	The acceleration profile about a gravitational body (GB) is described by a mathematical formula expressing the acceleration experienced by an object vs the distance of the object from the gravitational center of the GB.
Black hole	A spherical region of space where gravity prevents anything from escaping from the region. Question: How do gravitons escape a black hole?
Chandrasekhar limit	The Chandrasekhar limit is the maximum mass of a stable white dwarf.
Dark matter	‘Dark matter is a hypothetical form of matter thought to account for approximately 85% of the matter in the Universe’.
Degenerate matter	See Section 3.1
Electromagnetic force	Electromagnetic force is an interaction between electrically charged particles. The force is attractive between unlike charges and repulsive between like charges.
Event horizon	The spherical surface centered on a black hole at which the escape velocity from the black hole equals the speed of light.
Free fall	The motion of an object in a gravitational field where there is no electromagnetic force on the object. We cannot say that gravity is the only force on the object as an object is not subject to gravity.
Gravitational body (GB)	In this study, a gravitational body is a spherically symmetric, massive body such as a planet or star.
Gravitational compression	As particles of the TI field (TIPs) flow toward the center of a gravitational body (GB) the particle density of TIPs will increase without some counteracting agency.
Graviton	A graviton is the hypothetical elementary particle that mediates the force of gravity. Gravitons propagate at the speed of light.

Table 1 Glossary	
Term	**Definition**
Graviton flux	Graviton flux is a measure of the number of gravitons from a GB passing through a given area external to the GB per unit time. Graviton flux at a given distance from the GB is proportional to the acceleration at that distance.
Gravity	Gravity is one of the four fundamental forces in the Universe even though not acknowledged in the Standard Model.
Inertia	Inertia is a property of an object that enables the TI field to resist acceleration of the object relative to the TI field. See Section 6.3.2.
Inertial reaction force (IRF)	The inertial reaction force (IRF) is a force generated by the TI field and applied to an object as a function of the difference in acceleration between the object and the TI field.
Mass	There are three forms of mass: active gravitational mass, passive gravitational mass and inertial mass. 1. Active gravitational mass is a measure of the strength of an object's contribution to gravity. 2. Passive gravitational mass is a measure of an object's response to the gravitational force. 3. Inertial mass is a measure of the resistance by the TI field of the acceleration of an object relative to the TI field. See Section 6.3.2.
Massive compact object, MCO	A massive compact object is a white dwarf, neutron star or black hole.
Matter particle	I define matter particles by their properties of mass rather than by their constituents, e.g., sub-atomic particles. One or more matter particles comprise an object.
Newtonian model of gravity and inertia	'… Newton's law of universal gravitation… describes gravity as a force which causes any two bodies to be attracted to each other, with the force proportional to the product of their masses and inversely proportional to the square of the distance between them.'

Table 1 Glossary	
Term	**Definition**
Object	I define an object by its properties of mass rather than by its constituents. A matter object comprises one or more matter particles. A particle of the TI field (which is not a matter particle) may also comprise an object. The context in which I use the term object determines whether I mean a matter object or a particle of the TI field.
Particle density of the TI field	The number of particles of the TI field (TIPs) within a unit volume of space occupied by the TI field.
Particle flux	Particle flux is the rate of transfer of particles through a unit area per unit time.
Particle of the TI field	An elementary particle of the TI field. Properties and behavior of the TI field are described in Table A.1.
Process	a continuous action, operation or series of changes taking place in a definite manner’
Progenitor	A star or star system that produces a supernova.
Self-gravity	In the context of this study, self-gravity is the gravitational force exerted by a gravitational body on itself through the intermediary of the TI field. (Ordinary matter is not directly subject to gravity.)
Singularity	The hypothetical center of a black hole where the density of the black hole is infinite and the volume of the mass of the black hole is zero. As both these values are impossible, some mechanism must be at work to prevent the formation of a singularity.
Sphere of influence	The spherical volume centered on a massive compact object, MCO, in which the escape velocity from the object equals one-tenth the speed of light at the surface of the sphere of influence. Outside the sphere of influence, relativistic effects caused by the MCO are negligible.
Static field	A hypothetical field that resists the acceleration of particles of the TI field in its response to gravity.

Table 1 Glossary	
Term	**Definition**
Temporal Inertial (TI) field model of gravity and inertia	The Temporal Inertial (TI) field model is a conjecture of this author. This hypothetical model mediates the force of gravity. The TI field permeates all of space from the space within atoms to the expanse of the Universe. A few properties and behavior of the TI field are listed in Table A.1.
TIP	A particle of the TI field
White dwarf	A massive compact object with a mass of 1.4 to 2.1 solar masses and a radius of some 10 to 12 km.

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Appendix A

Properties of the Temporal Inertial (TI) Field in Brief

Table A.1 lists a few properties and behavior of the TI field.

Table A.1 Some Properties and Behavior of the TI Field
The TI field is a field of particles that participates in the inertial and gravitational interactions.
The TI field is subject to gravity.
Matter objects are not directly subject to gravity.
Particles of the TI field permeate space at every scale from subatomic to intergalactic and beyond.
When an object composed of matter particles is accelerated by an external force, its motion is resisted by its acceleration relative to the TI field. This reactive force of the TI field of space is the familiar inertial force.
Particles of the TI field are accelerated by gravity directly toward the center of each gravitational body just as a test particle would be and reaches the escape velocity of such a particle at the distance of that particle from the center of mass of the gravitational body.
The gravitational acceleration of the TI field relative to a matter object applies a force to that matter object. This force is the familiar gravitational force applied indirectly through the intermediary of the acceleration of the TI field of space.
The TI field accelerates matter objects at the same rate as its own acceleration.
Acceleration of the TI field in its own response to gravity is the sole accelerator of matter objects in response to gravity. Accordingly, massive objects are not directly subject to the gravitational force.
Acceleration of the TI field is moderated by a second field termed the static field.
The gravitational force on particles of the TI field is balanced by the inertial reaction force caused by the acceleration of the particles of the TI field relative to the static field.

Table A.1 Some Properties and Behavior of the TI Field
The TI field supports the propagation of nature's force particle particles, notably: photons and gravitons.
The speed of light and gravitons is their speed relative to the TI field.

Appendix B

The Model for the Creation of Dark Matter

B.1 Behavior of the Model for the Creation of Dark Matter

Let us review the model for the creation of dark matter given in reference [Richard A Peters] that summarizes the creation and behavior of dark matter excerpted here as Table B.1.

Table B.1 Behavior of the Model for the Creation of Dark Matter
The inertial mass of an object is proportional to the particle density of the TI field.
Relativistic effects notwithstanding, the inertial mass of an object is known to be constant throughout the Universe.
To maintain the constancy of the inertial mass of objects, the particle density of the TI field must itself be constant throughout the Universe.
As an aggregate of particles of the TI field (TIPs) flows toward a gravitational body (GB) it is subject to gravitational compression which, absent a counteracting agency, would increase the particle density of the field of particles.
Two processes counteract the gravitational compression of the TI field in the vicinity of a GB.
The first process is the transformation of TIPs into gravitons. The transformation rate of TIPs into gravitons is a function of the particle density of TIPs.
The gravitons produced in this first process comprise dark matter. The rate of creation of gravitons and thus the accumulation of dark matter is greatest where gravitational compression of the TI field is strongest, near gravitational bodies.
The transformation of TIPs to gravitons is a continuous process, a process that does not require the presence of a GB to compress the field of TIPs. We must assume that some other process exists that replenishes the particles of the TI field lost to gravitons. This other process must itself be continuous and self-sustaining.

Table B.1 Behavior of the Model for the Creation of Dark Matter
The second process is the spontaneous creation of TIPs from the vacuum energy of space. This process too is continuous and is independent of the particle density of TIPs.
The two processes work in concert to maintain a constant particle density of the TI field.
Even without the forcing function of gravitational compression (far removed from any GB), the transformation of TIPs into gravitons and the spontaneous creation of TIPs are continuous.
As a result of the processes described above, the Universe is suffused with gravitons that did not originate from any gravitational body.
The gravitons created in these processes add to the flux of gravitons emanating from active gravitational masses throughout the Universe (atoms, gas and galaxies).

B.2 The Particle Density of the TI Field is Constant Throughout the Universe

Table B.2 Rationale for the Constancy of the Particle Density of the TI Field
An object is not sensitive to the flux of TIPs. An object moves at velocity through the TI field without resistance.
An object is sensitive to the rate of change in the flux of TIPs caused by the acceleration of the object relative to the TI field.
The rate of change in the flux of TIPs seen by an accelerating object is proportional to the particle density of the TI field.
The resistance of an object to acceleration relative to the TI field is thus proportional to the particle density of the TI field.
The inertial mass of an object is a measure of its resistance to acceleration relative to the TI field.
The particle density of the TI field is thus a hidden parameter in the inertial mass of an object and heretofore has not even been contemplated.
As the inertial mass of an object is invariant, relativistic effects notwithstanding, the particle density of the TI field must be constant throughout the Universe.

B.3 The Transformation of TIPs to Gravitons Under Gravitational Compression of the TI Field

The table summarizes the arguments made so far and points to a resolution of the problems posed by gravitational compression of the TI field.

Table B.3 The Transformation of TIPs to Gravitons Under Gravitational Compression of the TI Field
TIPs are subject to gravity and are accelerated toward the center of a gravitational body (GB). Absent a counteracting agency, an aggregate of TIPs occupies a decreasing volume as it moves toward the GB. The particle density of TIPs thus rises as the field of TIPs is compressed by gravity.
To sustain the constant particle density of TIPs under gravitational compression of the TI field, TIPs must transform into a different type of particle, a particle with different properties.
The most stringent requirement for the new particle is that it must be massless. Why massless? Because all subatomic massive particles interact with the electromagnetic field which dark matter is not subject to by definition. (Free neutrons decay into protons and electrons.)
In the Standard Model of particle physics, the only massless particles are photons, gluons and, hypothetically, the graviton.
Of these particles, only the graviton has the properties that support a viable model of dark matter: • The graviton is massless, • The graviton asserts the gravitational force. • The graviton does not respond to the electromagnetic field.

B.4 Gravitons Comprise Dark Matter

Gravitons are my candidate for dark matter, not those emanating from a GB, but those produced by the transformation of TIPs into gravitons by gravitational compression caused either by a massive compact object, MCO, such as a white dwarf, white dwarf or black hole, or an extended GB, such as a galaxy or a cluster of galaxies.

B.5 The Creation of Active Gravitational Mass Without Matter

The flux of gravitons emanating from the transformation of TIPs caused by gravitational compression near a GB augments the flow of gravitons from the GB itself. This increase in graviton flux is equivalent to the graviton flux that would be created by adding active gravitational mass to the GB. This addition of active gravitational mass to the GB would increase the infall velocity of the TI field toward the GB and would increase the rate of conversion of TIPs into gravitons. This positive feedback would increase the mass equivalent of the GB indefinitely.

B.6 Conversion of TIPs into Gravitons

Particles of the TI field (TIPs) convert to gravitons under gravitational compression as the TI field flows into the white dwarf. This adds to the active gravitational mass of the entire volume surrounding the white dwarf and within the volume of the white dwarf itself. There is no time dilation of the conversion of TIPs into gravitons in the volume surrounding the white dwarf as time dilation occurs only in a process that is moving relative to the TI field, not by the motion of the TI field alone. This phenomenon is effective well beyond the sphere of influence of the black hole and increases the infall velocity of the TI field at the white dwarf.

The infall velocity of the TI field and the conversion of TIPs to gravitons is a process with positive feedback. As a result, the effective active gravitational mass of the volume about the white dwarf increases without bound, however slowly.