Analysis of the Concepts and Searching for Mini Black Hole

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Abstract. With the progression of time, individuals have an increasing desire and interest in the universe, and black holes, as perilous and enigmatic entities within the universe, naturally draw the attention of many individuals seeking to study them. Amongst all types of black holes, the mini black hole is particularly mysterious, and it remains unknown whether it even exists. This study will briefly introduce and integrate the concept of MBHs and their search. In fact, the life expectancy of a mini black hole is divided into four stages, which distinguishes it from other black holes. Ultimately, it will culminate in the production of short gamma ray bursts. Two methods for detecting mini black holes have been identified, one through gravitational waves and the other through Radio and X-Ray Sky. If the existence of MBHs is proven, some of the Universe's puzzles may be solved or explained. The paper's significance lies in its ability to provide a straightforward comprehension of mini black holes for individuals seeking further knowledge on the topic.

Keywords: Mini black holes; universe; gravitational waves; X-ray binaries.

1. Introduction

A proposition introduced by Stephen Hawking [1], mini black holes possess considerably less mass than typical black holes making their formation virtually unfeasible in the present cosmos. As the establishment of a smaller hole necessitates a greater degree of compression, the mass scales according to the inverse square of the density at which matter must be compressed. The density required for their formation is so high that it is currently unachievable. A hole the size of the sun has a density of approximately 10^{19} kilograms per cubic metre, surpassing that of an atomic nucleus. Currently, it is widely acknowledged that the highest density achievable through gravitational collapse is about as dense as can be found. This is due to the quantum forces of repulsion between subatomic particles which tend to stabilize lighter bodies than the sun, and consequently prevent them from collapsing. The smallest observed black holes weigh approximately six times the Sun's mass [2]. It is possible that miniature black holes emerged in an atmosphere of elevated temperature and pressure during the early history of the universe. Such miniature black holes offer a promising way to explore new physical theories, at the intersection of general relativity, particle physics, quantum mechanics, and cosmology [3]. Therefore, the investigation into mini-black holes is greatly significant because it has enhanced the quantum theory of gravity and opened up a new avenue in the general theory.

Contemporarily, extensive research has focused on mini black holes, namely the Mini Black Hole and Runaway Inflation Models. These simulations have demonstrated that during a stiff fluid dominating phase, heavy density perturbations collapse and form Mini Black Holes. Such a phase can materialize due to a runaway-inflation model that crosses an inflection point or sharp feature in the final stage of inflation. It is worth noting that Mini Black Holes rapidly dissipate and warm the early universe [4]. In addition, some researchers have found evidence of information loss for excited strings, also known as "string balls", in small black holes at the LHC. They have computed the transformation of information from compressed matter to the state of emitted Hawking radiation for these strings and concluded that the transformation for high energy strings is complete [5]. It is also believed by some researchers that small black holes may contribute to some portion of dark matter. Even if Mini Black Holes only make up a small portion of the density of dark matter, they may have significant effects and provide solutions to various cosmological issues. Moreover, large Mini Black Holes could potentially alleviate certain problems related to the conventional cold dark matter hypothesis, while extremely huge ones could serve as the seeds for supermassive black holes in galactic nuclei [6].

This article is inspired by the absence of a proof for its existence, but it is a crucial component of the comprehensive general unity theory. This theory successfully unifies the principles of general relativity, quantum mechanics, and thermodynamics, making it a fascinating topic. As discussed by Hawking, it is beneficial to study something in spite of its non-existence. The objective of this paper is to integrate the existing knowledge and discoveries of mini-black holes in a clear and straightforward manner. This article is structured into six sections. The first section serves as an introduction to black holes, while the second section deals with mini black holes. The third and fourth sections elaborate on the searching scheme and application of mini black holes, respectively. The fifth section focuses on limitations of the current stage and prospects for the future. The final section consists of a succinct summary of the article.

2. Basic Descriptions

There are four distinct categories of black holes in the Universe, categorized by their mass: Stellar, Supermassive, Intermediate and Primordial (commonly referred to as Miniature Black Holes). The formation of each specific type of black hole has its own individual characteristics. This article seeks to outline the unique attributes of each kind of black hole.

Stellar black holes typically form as a result of a star depleting its fuel. The cessation of the life cycle of massive stars is determined by various factors, of which include metallicity, binarity, angular momentum, nucleosynthesis, and neutrino transport during explosions. According to most models, massive stars can undergo collapse to create black holes [7].

Supermassive black holes exist at the centre of almost every large galaxy. These colossal objects have masses ranging from hundreds of thousands to billions of times that of the Sun, and are believed to be a potential power source for some quasars. These colossal objects have masses ranging from hundreds of thousands to billions of times that of the Sun, and are believed to be a potential power source for some quasars. The formation of supermassive black holes remains a mystery, with several theories yet to be confirmed. These colossal objects have masses ranging from hundreds of thousands to billions of times that of the Sun and are believed to be a potential power source for some quasars. The text already adheres to the principles or lacks context, therefore no changes are necessary.

Intermediate black holes are a type of black hole that exist between stellar-mass black holes and supermassive black holes, and due to the large gap between these two types of black holes, it is possible that another type of black hole exists in between. However, there is currently no conclusive evidence for their existence, although there have been many identifications of potential intermediate black holes.

Mini-black holes formed in the first seconds after the birth of the Universe. The conditions for their formation ceased as the Universe rapidly expanded and cooled. Presently, there is no proof of the existence of these miniature black holes. However, based on the quantum mechanical processes occurring at the edge of the event horizon, it is possible that they will start to disappear as the Universe gets older. According to Hawking's radiation theory, low-mass black holes will evaporate more quickly than larger ones, suggesting that several mini black holes may have already vanished. However, it is still possible that there are other large mini black holes out there in the cosmos.

3. Principle

In this section of the paper, the theory of mini black holes will be introduced specifically about mini black holes. A mini black hole is different from other black holes in that it has four stages in its life which are (1) 'balding', (2) spin down, (3) Hawking evaporation, and (4) Planck stage [8]. The third phase, Hawking radiation is the most important of these four phases, and it is here that most studies have focused. Tan produced a model of black hole mass and and time based on the phases of Hawking radiation also known as Eq. (1) [9]:

$$M = \sqrt[3]{-\mu M_0^2 t + M_0^3} \tag{1}$$

Based on Eq. (1), Tan obtained the black hole mass and time relationship as shown in Fig. 1. The initial mass of the black hole in this model is 10^{11} kilograms. Once it reaches the Planck mass, it will be presented as a vertical line on the diagram, demonstrating that its mass has reduced to zero. However, this model only pertains to large miniature black holes, given that the Hawking temperature of such enormous black holes is significantly lower than the temperature of microwave radiation that is appropriate for utilization in the universe. Due to the imperfect nature of a black hole as a black body, it still has the ability to absorb additional radiation from space. Therefore, it is likely that these black holes absorb more radiation than they emit, leading to an increase in their mass until their temperature exceeds the cosmological value [10].

The evaporation at the end of the mini-black hole could potentially cause the burst of short gamma rays. The bimodality of the burst duration variable T (time taken for 90% of the flux to arrive) is evident, indicating that two different types exist, as proposed by Kouveliotou in 1993 [11]. There are two different gamma-ray bursts divided by a $T \cong 2s$. Therefore, it is imperative to calculate the duration for an mini black hole to release 90% of its current mass via Hawking radiation to confirm if it causes the outburst. This process will then enable the equalization of the loss with 90% of the residual mass energy to establish an equation for T, which is autonomous to t and dependent only on the current mass of the MBH:

$$T_{90} = \frac{0.999M^3}{\mu M_0^2} \tag{2}$$

In Tan's model, the mass of the black hole is set at 10 to the power of -6 times the initial mass of the black hole, resulting in a T value of 0.4354s. With a value less than 2, it indicates that the evaporation of the Mini black hole at the end of its life may be responsible for short gamma-ray bursts in the Universe [9].

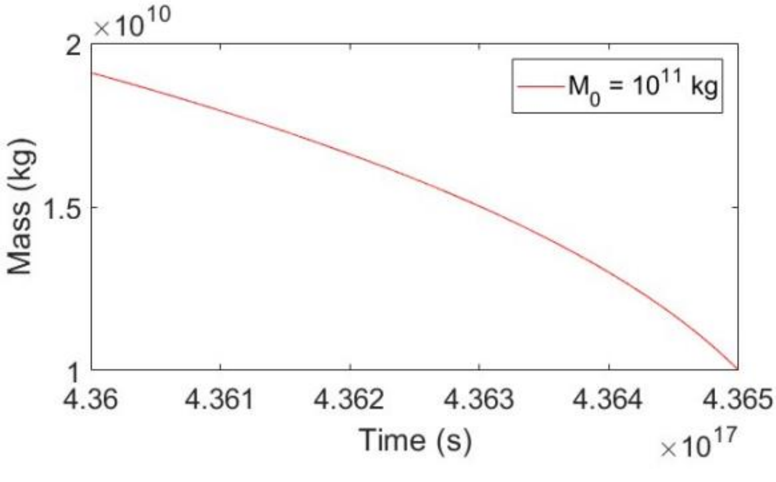

Fig. 1 Mass-time relationship.

4. Searching Scheme and application

In this section of the paper, the current detection of mini-black holes and the applications of mini-black holes will be introduced. Most of the detections of small black holes to date have originated from the observation of gravitational waves by LIGO/Virgo. Subsequently, the small black holes were modelled to obtain the ultimate results and to compare them with the observed data. For instance, Fig. 2 displays the visible distribution of effective spin against q as illustrated in Ref. [12]. These diagrams indicate a significant connection between χeff and q when accretion is significant. In the event of a lack of accretion, the effective spin parameter becomes zero as a result of the starting conditions. This is because the initial spins' conditions lead to parameter vanishment. Initialisms of technical terms must be explained after first use. While the Ref. [12] showed that the LIGO and Virgo events are inconsistent with the primordial origin of black holes in the absence of accretion, the case remains open in the presence of accretion. The authors expect that the O3 project and the data from the Advanced LIGO Survey will be used to help resolve this question.

In reference [13], the gas accretion of various MBHs in the Milky Way has been modelled by researchers, and the resulting radio and X-ray emissions have been compared with observational data. The results show that the idea that $O(10)\ M_{\odot}$ MBHs could account for all the dark matter in the Galaxy, assuming an accretion process, is invalid when compared with a 1.4 GHz Very Large Array radio table at 5σ. Similarly, the possibility that $O(10)\ M_{\odot}$ MBHs could account for all the dark matter in the Galaxy is ruled out by comparison with a Chandra X-ray table at 40σ. Furthermore, it is suggested that this technique may detect a cluster of mini black holes using forthcoming, more precise radio and X-ray surveys [13].

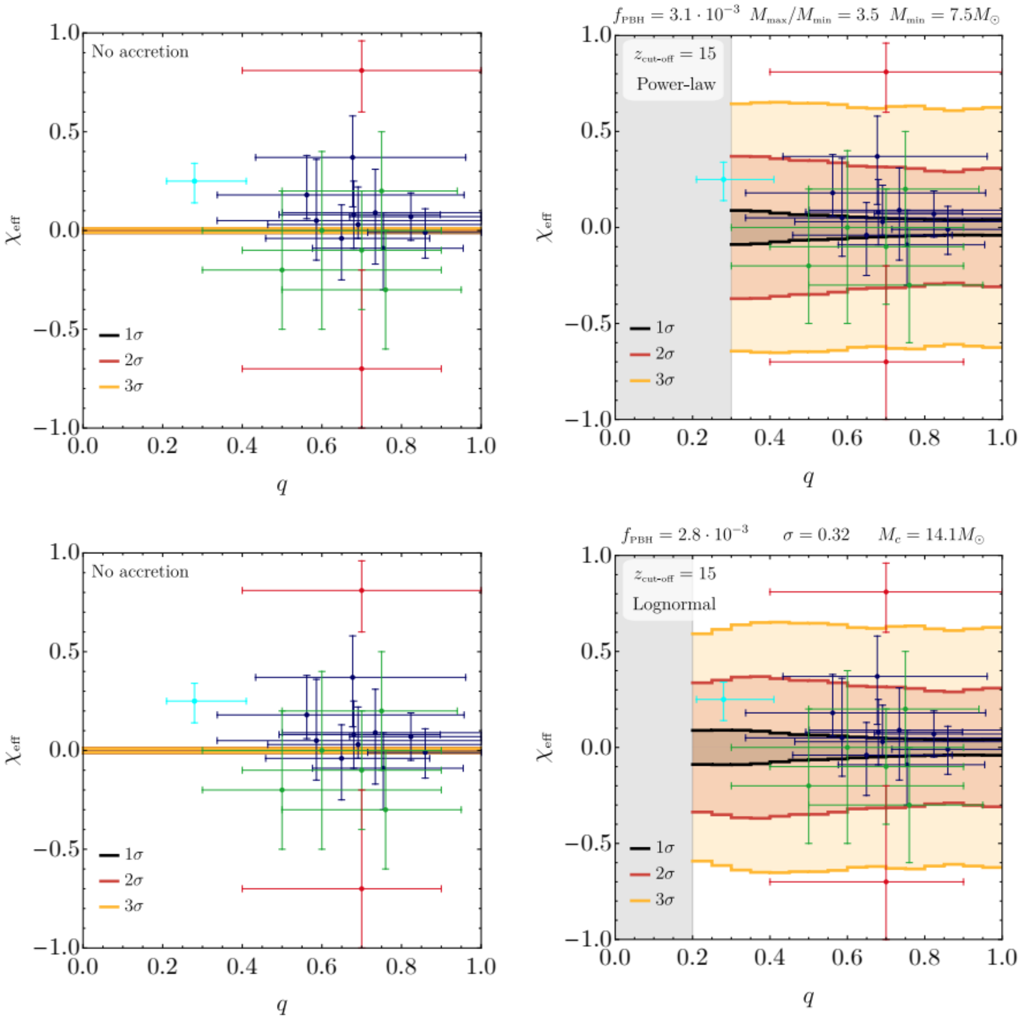

Fig. 1 The available data for both the power-law (first block) and log-normal (last block) mass functions are compared with the observable distribution of the effective spin as a function of q.

Meanwhile, the presence of mini-black holes may elucidate part of the cosmic mystery. For instance, as stated in reference [14], there are several puzzles to be addressed including Microlensing of planetary masses, microlensing of quasars, the excess of dark lenses in the Galactic bulge detected by OGLE/GAIA, X-ray and infrared cosmology, UFDGs, mass, spin and merger rates for LIGO/Virgo black holes, and intermediate-mass and supermassive black holes (IMBHs and SMBHs). Clearly, clarifying these puzzles is conditional on the MBH mass function with $\tilde{n}_s \simeq 0.96$. If Mini black holes constitute the entirety of dark matter, their expected mass function, based on the Universe's known thermal history, can potentially resolve diverse cosmic enigmas. MBHs from the

"W/Z" bulge are too small to be observed by LIGO/Virgo, but they may be detectable through micro-lensing and could already have been identified in the OGLE data. MBHs from the "electron" bulge are too large to be detected by LIGO/Virgo. However, it is possible to observe the dynamical effects of intermediate-mass black holes in dwarf spheres or supermassive black holes in galactic nuclei, providing a rationale for correlating their masses with that of the host halo [14]. A range of astronomical observations could potentially reveal additional features in the mass functions of MBHs, provided that conclusive evidence is discovered. Such observations could detect the presence of new particles that are thermally linked to the primordial plasma. Furthermore, this suggests that MBHs are an excellent tool for studying phase transitions in cosmology, which are responsible for its formation.

5. Limitations and Prospects

There are numerous limitations in this field, most notably the unfeasibility of pinpointing authentic miniature black holes. As a result, the majority of suppositions about miniature black holes are based on projections and simulations, which, in turn, may not align with real circumstances. This discrepancy can be attributed to the issue of observation machinery. Hawking radiation is not easily observable and gravitational waves can arise not only from small black holes but also from the mergers of black holes, resulting in multiple effects. Of course, these two issues are interlinked as mini black holes cannot be directly observed and must be simulated. Apparently, these two issues are interlinked as mini black holes cannot be directly observed and must be simulated. However, simulation errors can lead to a limited understanding of these objects, presenting difficulties in observing them. Advancements in one area are likely to have a positive knock-on effect on the other field. Of course, these two issues are interlinked as mini black holes cannot be directly observed and must be simulated. Of course, it is also possible that miniature black holes do not exist at all. However, whether they exist or not, studying them will enhance my comprehension of astronomy, black holes, and the early universe. Disproving their existence would be as rewarding as proving it. It is anticipated that in the future, with the progression of black hole detection technology, there will be more precise apparatuses to explore the miniature black hole. This may lead to an identification of its existence.

6. Conclusion

The main focus of the paper is an objective analysis of the concept and definition of mini black holes. The paper outlines the classification of black holes and explores the lifespan and short gamma ray bursts of mini black holes. Additionally, the paper briefly describes the detection of mini black holes and their role. Furthermore, the paper acknowledges the limitations of research on mini black holes at this stage and avoids biased language. One limitation is the inability to detect Hawking radiation with current technology, while another limitation concerns our understanding of miniature black holes. These limitations are interrelated. A redefinition of miniature black holes may offer a fresh perspective for detection. The objective of this study is to provide a concise overview of current information regarding mini black holes, allowing readers to gain a basic understanding of the topic. It is expected that future advances in science and technology will make it possible to carry out more extensive research on miniature black holes.

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