

## Black Hole Project: M33 X-7

For my final project for introduction to blackholes, I made a creative musical piece to describe my black hole, M33 X-7, the most massive stellar black hole that was not discovered with gravitational wave detection. This musical piece will feature me playing midi instruments and singing vocals. I also edited it using Logic X to make it a multi-instrumental song. The piece is a rap that uses the X-ray binary black hole M33 X-7 as a metaphor for two lovers coming together. The rap is sung from the perspective of one lover, the companion star, who is caught by the black hole's gravity, the other lover. The rap is chronological, starting from when the two celestial objects are caught by each other's gravity, and how the blackhole accretes the companion star's mass. This represents the couple's first interaction and exchanging of interests. Then, when the companion star becomes a blackhole as well, the couple have become similar to one another and are more serious about each other. Then, the end of the rap depicts the eventual future of the couple as a unified blackhole that slowly evaporates away through hawking radiation. This is symbolic of the couple the living of the rest of their life together.

I will address each assessment point while referencing the lyrics copied below who's lines have been numbered.

Citations to physical parameters and the Black Hole's discovery are copied in an References section at the end.

### Physical Parameters

- [Verse 5] The mass of the blackhole, exclusive of the companion star, represents the pull and interest of one of the lovers. It is referenced to be 15 Solar masses. In reality it is  $(15.65 \pm 1.65)$  Solar masses.
- [Verse 4] The temperature represents the heat of their relationship. The temperature of the X-ray Binary is referenced to be equivalent to 7 suns. In reality it is about  $(35000 \pm 1000)$  Kelvin which is about the temperature that 6 suns summed together would produce (1 sun = 5778 Kelvin)
- [Verse 5 & 6] The periodicity of my Black hole is  $(3.45301 \pm 0.00002)$  days. The periodicity is representative of how long the two lovers spend time apart from each other, but eventually come back to each other. In the rap, there is reference to this periodicity being 3.5. There is also a snare drum that hits every 3.5 beats within a bar throughout the song. This beat is most noticeable in verse 5, and in the lyrics I have underlined which syllables are stressed in the rap to highlight the snare beat.
- [Verse 4 & 18] The x-ray binary is directly referenced to be about 3 million light years away in the Triangulum galaxy. It is in reality  $(2.7 \pm 0.07)$  million light years away. This quantity is analogous to how isolated the couple feel from everyone else.
- The right ascension of the x-ray binary is indirectly referenced in the length of the rap. Starting from the first vocals in Verse 1 to the Chirp after verse 14. The right ascension is 1h 33m 34.13s. In reference to the units of measurement, the period in which the vocals are in place roughly makes up 1m 35 seconds,

### What does the black hole look like?

- [Verse 2] The companion star is referenced to be an O-type star (in how it starts with "Oh!"), and how such a star would be very hot, resulting in the said "blue face"

colour. The fact that the Companion star is the most massive companion star for a blackhole we know of is referenced to how he is a “Big hot star”.

- Throughout the song, the rap makes references to how it is a binary system and the two celestial bodies revolve around each other doing a “spinning” “circling in orbit”.
- [Verse 3] References how X-ray binaries are some of the most luminous things in the sky while also showing how “bright” the two companion’s relationship is.
- [Verses 9 & 11] These reference the existence of an accretion disk, because the black hole accretes (“takes it all away”) the companion star’s mass.
- [Verses 15 & 16] These reference how generic blackholes look like, how more mass grows the Schwarzschild radius and how at the event horizon, not even light can escape a black hole’s gravitational pull. These statements are allusions to the scope of the two’s love for each other.

### **How does your black hole affect its environment?**

- As priorly mentioned, the rap describes how there is an accretion disk as well as the x-rays that come from it. Aside from this. The rap also discusses the future, when the companion star erupts in a supernova [Verse 10], Then there exists a black hole binary [Verse 11], and the eventual merging of these two that generates a gravitational wave across space-time [Verse 13]. This gravitational wave can interact with its surrounding environment by compressing and stretching space like “push and pull their hearts” [Verse 14]. It also discusses how blackholes will trap light across the event horizon [Verse 16]

### **How was the black hole discovered/detected?**

- According to a Reference 2, M33. X-7 was detected by NASA’s Chandra X-ray Observatory and the Gemini Telescope. By observing X-ray sources in the nucleus of a star-forming region. 261 Sources were given a luminosity function, using that M33 X-7 was clearly detected to be an eclipsing binary. Its discovery was aided by detecting the movement of the companion star. I suspect the latter is partially measuring the ellipsoidal variations in brightness of the companion star revolving around the blackhole. These two detection methods are referenced in how when the companion star “spins around and around, the entire world can tell” [Verse 8] as well as how when the companion star dies and becomes part of an black hole binary, “the world cannot find [them] because the accretion [disks] cease to be.” [Verse 11]

### **How was this black hole formed?**

- I did not discuss much about how the black hole was formed because it is not exactly clear. One of the models used to describe the formation of this blackhole involved the death of a very massive star with a radius bigger than even the distance between the black hole and companion star. However, this model is debatable because such an event would result in a loss of a lot of the star’s mass, not enough to sustain the 15 Solar mass blackhole we find. Another model (reference 3) proposes a binary star system with a primary being about 100 Solar masses and the secondary being 30 Solar masses. The primary transferred some of its mass to the secondary as it’s stellar envelope increased and also lost some mass due to stellar wind. Eventually the primary star collapsed to form the blackhole and the secondary became the O-type star we see today. Either way, at some point the celestial objects must have caught

each other through gravitational attraction. This is why the song in the beginning [verse 3] discusses the first meeting of these two celestial objects, and how they are caught in each other's gravity.

- I do go more into depth of the future of the binary, and how they will form a black hole. Because the companion star will eventually die, in a supernova [Verse 10] causing a binary blackhole system [Verse 11]. And then in a long time later the two blackholes will merge, creating on causing gravitational waves [Verse 12 & 13]
- Once they merge, the two have become one more massive blackhole. This is the final stage of the binary as it will simply be there (all things equal), left to only evaporate through hawking radiation, which is referenced in verse 17 saying "Things are popping in and out (particle/antiparticle pairs) till our love (mass) evaporates". This is analogous to time and events coming in and out of the couple's lives and how love may "evaporate" with time.

### **What risks do the black hole present to us, and how does the black hole interact with the Earth?**

- The blackhole, being 3 million light years away, doesn't present any direct effects to us here on earth. But it does imply an event in the future, the merging of two blackholes, that is one of the most violent disturbances in the universe. As discussed many times, their collision [Verse 12] sends gravitational waves, as described by Einstein and GR, that moves through the universe. ("the maze" "reach the worlds") This figuratively "shakes our world" because of the effect gravitational waves has on special distances (stretch and compression), but it also presents a discovery that shakes the scientific world to physicists and LIGO.
- The project does not reference the BH's effect on nearby objects, but for the sake of clarity, such a blackhole would exert tidal forces. Like for example it's companion star, it exerts stronger gravitational forces for parts of the star closer to the BH than parts of it further away.

### **Other notes of symbolism in the song left to be said:**

There is a flute playing a melody in the background that plays a much more toned down version of the bass riff from the song "Super massive blackhole" by MUSE.

Throughout the song, I sampled the sounds of two blackholes colliding, collected by LIGO. as found in the video: <https://www.youtube.com/watch?v=QyDcTbR-kEA>. You can hear this "chirp" half way through every line. There is an even louder chirp that is more noticeable. That chirp marks the 1m33s amount of time after starting to sing/rap. (Verse 14, "Let the sound unfurl")

## Lyrics to M33 X-7

[1] M33 X-7, my heaven. The blackhole just right for me x2

[2] O! I'm a big hot star, and I got the looks. But suddenly when you caught me, I show my blue face.

[3] I'm caught in this ruse. And I refuse to let you go. And we let loose the biggest baddest black hole ever introduced.

[3] We can send x-rays so strong, we blow the minds of all the, commoners. And Bright up the sky for the astronomers.

[4] Become something so big so hot, were blazing like 7 suns. This is our sum. Galaxy Triangulum.

[5] You and me, M33 X-7, we be. Black hole binary. Spinning so rapidly.

[6] Periodicity 3.5 days your away from me. How long will it be, till we clash, start officially.

[7] You got me circling in orbit around 15 suns. Pulling me close day by day and we play this game for months.

[8] I spin around and around, then entire world can tell. That we are here, that you're my black hole, I cannot farewell.

[9] Look at me now, cause I get smaller day by day. For long time till you take, take it all away.

[10] Till you see me supernova it's all over, it's a cross over. Destiny is your wisdom, binary black hole system.

[11] And now we're the same. I'm drawn to you, you're drawn to me. The world cannot find us cause The accretion ceased to be.

[12] Now we dance alone endlessly. Till we fill the void with our ripples, like Einstein said in his general relativity.

[13] Gravitational waves, moves through the maze and reach worlds. They know who we are, shatter their world.

[14] Let the sound unfurl...Push and pull their hearts, singularities kick start, representations drawn by art.

[15] On top of all this craziness we've grown the Schwarzschild radius.

[16] Cause we've reached new horizons where no one, not light, can hide in.

[17] Reading our last page, we could spend the rest of days. Things are popping in and out and so our love evaporates.

[18] No one can touch us, 3 mill light years far away. We are here to stay. Together today, all worries away.

## References

1.

Dunbar, Brian. "Heaviest Stellar Black Hole Discovered in Nearby Galaxy." *NASA*, NASA, [www.nasa.gov/mission\\_pages/chandra/news/07-112.html](http://www.nasa.gov/mission_pages/chandra/news/07-112.html).

2.

Grimm, H.-J., et al. "The X-Ray Binary Population in M33. I. Source List and Luminosity Function." *The Astrophysical Journal Supplement Series*, vol. 161, no. 2, 2005, pp. 271–303., doi:10.1086/468185.

3.

Valsecchi, Francesca, et al. "The Intriguing Evolutionary History of the Massive Black Hole X-Ray Binary M33 X-7." 2010, doi:10.1063/1.3536386.