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Is Virgil Van Dijk a Defensive Black Hole?

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Abstract
Virgil van Dijk is widely known as the best Premier League defender of his generation and is argued to be one of the greatest football defenders of all time. His unique defensive prowess often makes it seem like nothing can get past him, anticipating where he needs to position himself like no other with the ball often seeming like it is drawn to his feet. This journal explores if his defensive dominance is down to his presence or as fans describe it, "defending with aura", analysing this through the lens of physics, in particular black holes and the gravitational fields they generate. Although the concept of Van Dijk being a literal black hole is physically impossible, his ability to pull attackers and the ball into his control is very real.

Keywords: *Sports; Physics; Gravity; Football; Liverpool*

Introduction
In football, central defenders are vital in dictating play, neutralising attacks and controlling the defensive line, and Virgil Van Dijk is a master at all of these. Using these talents, he commanded Liverpool to their 6th Champions League title in the 2018/19 season [1], double that of rivals Manchester United (3) [2] and the following year, he was part of the historic team that won Liverpool's first league title in 30 years, finishing with a club record of 99 points [3]. In 2024, he captained the Netherlands to their first Euros semi-final since 2004 [4] and is now the Liverpool first team captain [5].

Van Dijk's influence is undisputed and even extends to opposition players, with attackers often avoiding *1-v-1* situations with him. When attackers do take him on, Van Dijk uses his unique defending style, either pushing them out wide or patiently biding his time until the last second, sticking a leg out to block the shot (figure 1). Many football fans have labelled his defending style as "defending with aura" [6], calmly and decisively dealing with goal threats.

This paper investigates whether Van Dijk's defensive inevitability stems from his 92kg, 1.95m frame [7] forming a black hole, distorting space-time and creating a gravitational pull strong enough to bend light or draw the ball to his feet.

Figure 1 – Van Dijk holding off Erling Haaland [8].

Principles of Black holes
According to Einstein's general theory of relativity, any object with mass curves space-time, creating a gravitational field [9]. The strength of the field depends on the mass of the object and the distance from it [10].

In black holes, mass is so densely concentrated that the curvature of space-time creates a pull of gravity so strong that not even light can escape [9]. This boundary is called the event horizon, beyond which everything is drawn towards the singularity—a point of infinite density at the black hole's centre [11].

Black Hole Calculations

For black holes to occur, there must be a sufficient mass crammed into a small enough area [9]. The Schwarzschild radius is the distance from the centre of a black hole below which not even light can escape and is used to determine the maximum radius of a spherical mass that could cause a black hole [12]:

$$R = \frac{2GM}{c^2},$$

where R is the Schwarzschild radius (m) and G and c are the constants:

$$G = 6.67 \times 10^{-11} Nm^2 kg^{-2},$$
$$c = 3 \times 10^8\ ms^{-1}.$$

The equation can also be written as:

$$R = 1.49 \times 10^{-27} \times M.$$

Van Dijk's mass [7]:

$$M = 92\ kg.$$

Substitute for M:

$$R = 1.49 \times 10^{-27} \times 92 = 1.37 \times 10^{-25}\ \text{m}.$$

This means for Van Dijk to cause a black hole at his existing mass, he would need to be compressed into a sphere with a radius below $1.36 \times 10^{-25}\ m$. This is incredibly small, for reference, the classical electron radius is $2.82 \times 10^{-15}\ m$ [13], approximately 10 billion times larger than the size that Van Dijk would have to be to cause a black hole.

Could a Micro Black hole exist Inside Van Dijk?

Although Van Dijk is far too big to be a defensive black hole at his mass, it is theoretically possible for a micro black hole to exist inside of him. A stable primordial black hole from the early universe could persist inside Van Dijk and draw the football towards his feet. Unfortunately, for a micro black hole to survive since the start of the universe it must be small enough to evade Hawking radiation and its gravitational effects would be negligible [14]. Our current understanding of physics suggests that micro black holes would evaporate almost instantly [15], making this scenario purely hypothetical and incredibly unlikely.

How Many Van Dijk's Would Form a Black Hole?

The maximum mass that a neutron star can reach before it collapses into a black hole under its own gravity is known as the Tolman-Oppenheimer-Volkoff limit (TOV, approximately $4.65 \times 10^{30}\ kg$ [16]).

To find the minimum number of Van Dijks needed to form a black hole, he would need to be compressed down into a sphere with the density of a neutron star. Every additional Van Dijk must be added at the same density and spread evenly over the existing sphere to maintain the uniform shape.

Minimum mass of black hole from collapsed neutron star:

$$TOV = Mass\ of\ Van\ Dijk\ (M) \times No.of\ Van\ Dijks\ (N).$$

$$N = \frac{TOV}{M},$$

$$N = \frac{4.65 \times 10^{30}}{92} = 5.05 \times 10^{28}\ Van\ Dijks.$$

5.05×10^{28} is an extraordinary number of Virgil Van Dijks that would have to be compiled to form a black hole. For some context, its approximately 50,000 times larger than the number of stars in the observable universe (approximately 1×10^{24} [17]) and 6.7 billion times the number of grains of sand on Earth (approximately 7.5×10^{18} [18]).

Conclusion

The concept of Virgil Van Dijk being a defensive black hole may be true metaphorically but is very unrealistic. He would need to be compressed by a physically impossible amount into a radius far smaller than even subatomic particles. While a micro black hole inside him is theoretically possible, it would evaporate almost instantly due to Hawking radiation. Luckily for the Netherlands and Liverpool, Van Dijk doesn't need a black hole to suck attackers into his orbit.

References

[1] UEFA, (n.d.). *2018/19 UEFA Champions League season*. UEFA. Available at: https://www.uefa.com/uefachampionsleague/history/seasons/2019/ [Accessed 27 January 2025].

[2] Manchester United, (n.d.). *European Cup & Champions League*. Manchester United. Available at: https://www.manutd.com/en/history/trophy-room/european-cup-champions-league [Accessed 27 January 2025].

[3] Premier League, (n.d.). *2018/19 Season Review*. Premier League. Available at: https://www.premierleague.com/history/season-reviews/274 [Accessed 27 January 2025].

[4] UEFA, (n.d.). *Netherlands: All their EURO records and stats*. UEFA. Available at: https://www.uefa.com/euro2024/news/0269-1237d682ebdb-455145537227-1000--netherlands-all-their-euro-records-and-stats/ [Accessed 27 January 2025].

[5] Liverpool FC, (n.d.). *Virgil van Dijk*. Liverpool FC. Available at: https://www.liverpoolfc.com/team/mens/player/virgil-van-dijk [Accessed 27 January 2025].

[6] OneFootball, (2025). *Virgil van Dijk adds another classic highlight to his aura defending*. OneFootball. Available at: https://onefootball.com/en/news/virigl-van-dijk-adds-another-classic-highlight-to-his-aura-defending-40572229 [Accessed 27 January 2025].

[7] Wikipedia, (2025). *Virgil van Dijk*. Available at: https://en.wikipedia.org/wiki/Virgil_van_Dijk [Accessed 27 January 2025].

[8] Getty Images, (n.d.). *Virgil Van Dijk of Liverpool holds off Erling Haaland of Manchester City*. Available at: https://www.gettyimages.co.uk/detail/news-photo/virgil-van-dijk-of-liverpool-holds-off-erling-haaland-of-news-photo/1433863801 [Accessed 27 January 2025].

[9] NASA, (2020). *Einstein and General Relativity*. NASA. Available at: https://www.nasa.gov/image-article/einstein-general-relativity/ [Accessed 27 January 2025].

[10] Mattson, B (2015). *100 Years of General Relativity*. NASA Blueshift. Available at: https://asd.gsfc.nasa.gov/blueshift/index.php/2015/11/25/100-years-of-general-relativity/ [Accessed 27 January 2025].

[11] NASA, (n.d.). *Anatomy of a Black Hole*. NASA Science. Available at: https://science.nasa.gov/universe/black-holes/anatomy/ [Accessed 27 January 2025].

[12] NASA, (2013). *Black Hole Math – Using the Schwarzschild Radius to Explore Black Holes*. NASA Space Math. Available at: https://spacemath.gsfc.nasa.gov/weekly/4Page27.pdf [Accessed 27 January 2025].

[13] Bruskiewich, P. (2004). *Revisiting the Classical Electron Radius Using Modern Empirical Concepts*. ResearchGate. Available at: https://www.researchgate.net/profile/Patrick-Bruskiewich/publication/383022950_Revisiting_the_Classical_Electron_Radius_Using_Modern_Empirical_Concepts/links/66b80d742361f42f23c7f427/Revisiting-the-Classical-Electron-Radius-Using-Modern-Empirical-Concepts.pdf [Accessed 27 January 2025].

[14] Wald, R.M. (2001). *The Thermodynamics of Black Holes*. Living Reviews in Relativity, 4(1). Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC5253844/ DOI: 10.12942/lrr-2001-6 [Accessed 19 February 2025].

[15] NASA, (2024). *Types of Black Holes*. NASA Science. Available at: https://science.nasa.gov/universe/black-holes/types/[Accessed 27 January 2025].

[16] Crosswell, K. (2022). *Heaviest known neutron on record is 2.35 times the mass of the sun.* Science News. Available at: https://www.sciencenews.org/article/heaviest-neutron-star-mass-sun-record-black-holes [Accessed 27 January 2025].

[17] Diplex Tech Nomad, (2023). *Are there more stars in the universe or grains of sand on Earth?* Medium. Available at: https://drdiplextechnomad.medium.com/are-there-more-stars-in-the-universe-or-grains-of-sand-on-earth-b803364dadfe [Accessed 27 January 2025].

[18] NASA, (2024). *Star Basics*. NASA Science. Available at: https://science.nasa.gov/universe/stars/ [Accessed 27 January 2025].