SIGSEVEN

Various Ramblings on Algebraic and Superalgebraic uses of Heegner Numbers

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Abstract

Some of you, including the person who runs the SIGBOVIK Bluesky Account, will have seen my skeet [1] announcing roughly what I would submit for this conference. Unfortunately, nobody reached out, and none of the people I had talked to were willing to participate. So, I have instead decided to write this paper as a series of vignettes, surrounding various numbers, but of course, 67 in particular.

1. Introduction

Lately, many children (and others who wish they were children) [2] have been repeating the phrase "6-7". The phrase has its origins in the song *Doot Doot (6 7)* [3], and its meaning has been theorized to various things. There exists much better coverage of the societal and cultural impact of the meme than this paper. Instead, I want to try and explain the number from a mathematical perspective and from other, more niche, meme perspectives.

One of the main pillars of SIGBOVIK is its unique coverage of the other three quadrants of the serious-joke idea and realization table. However, to get to the joke idea's serious realization, I must first present some serious mathematics seriously, so I ask that you stick with me while I do so. I can't promise it will be worth it, but it's all I can ask for.

2. Heegner numbers

Wikipedia states that "a Heegner number ... is a square-free positive integer d such that the imaginary quadratic field $\mathbb{Q}\left[\sqrt{-d}\right]$ has class number 1" [4]. A square-free integer is an integer which has no square numbers as factors, besides 1 [5]. This is the only simple part of that definition.

2.1. Fields

Fields themselves are a relatively simple concept. Real numbers are a field, as are the rationals and complex numbers. More precisely, they are defined as "a set on which addition, subtraction, multiplication, and division are defined and behave as the corresponding operations on rational numbers do" [6].

Fields can be extended, as demonstrated by complex numbers being an extension of the real numbers. Conversely, real numbers are a subfield

*Hey, I have my own domain mail this time. Isn't that cool?

†I feel like the date has been moving further from April 1 every year.

of the complex numbers [7].

Field extensions can have a "degree", almost similar to that of a polynomial. By extending a field, that extension can be quantified by the "vector-space" that it provides in addition to the original field. For example, the complex numbers exist orthogonally to the real numbers, so the complex field extension has degree 2 [8].

Wikipedia notes that algebraic number fields are extension fields of the rational numbers that have finite degrees [9], and a quadratic number field is an algebraic number field with degree 2 [10].

Algebraic number fields can have a class group and class number. This is the point at which I stop being able to grasp the concepts. Rather than trying to explain any further, I will simply give the example of the field $\mathbb{Z}[i]$, which represents the Gaussian integers, or essentially the integer version of complex numbers. They have a class number of 1. The only negative integers for which $\mathbb{Q}(\sqrt{d})$ has a class number of 1 are $-1, -2, -3, -7, -11, -19, -43, -67, -163$, and here we see our Heegner numbers, although negative.

2.2. Applications

So now that we have these numbers, what can we do with them? Not much. The most interesting thing to result from these numbers is the series of almost integers $e^{\pi\sqrt{d}}$. Technically, only the last four of the numbers are close enough to be considered almost integers by most[1], but I cherry-picked some more of them here to provide more context (and length) for readers.

d	$e^{\pi\sqrt{d}}$
2	$85 + 0.01$
7	$4072 - 0.0679$
43	$960^3 + 744 - 0.00022$
67	$5280^3 + 744 - 0.00013$
163	$640320^3 + 744 - 0.00000000000075$

They also show up in other things like the Chudnovsky algorithm for calculating pi. Specifically, the presence of the number 163 in

$$\frac{1}{\pi} = 12\sum_{k=0}^{\infty} \frac{(-1)^k (6k)!(545140134k + 1351409)}{(3k)!(k!)^3 (640320)^{3k+3/2}}$$

where $545140134 = 163 \cdot 3344418$, is a result of the j-invariant

$$j\left(\frac{1+\sqrt{-163}}{2}\right) = -640320^3$$

[11]. Also, Ramanujan's several pi formulae were generalized as the Ramanujan-Sato series, of the form

$$\frac{1}{\pi} = \sum_{k=0}^{\infty} \frac{(4k)!}{k!^4} \frac{26390k + 1103}{396^{4k}}$$

[12]. This does give the possibility of an approximation for pi based on $e^{\pi\sqrt{67}}$, being

$$\frac{1}{\pi} = 12\sum_{k=0}^{\infty} (-1)^k \frac{(6k)!}{k!^3 (3k)!} \frac{2 \cdot 3^2 \cdot 7 \cdot 31 \cdot 67k + 10177}{(5280^3)^{k+1/2}}$$

as noted by Piezas [13].

There's the punchline, by the way. At least, I hope that that's a punchline.

2.3. Tangent: Is any of this even funny?

Tom7 notes that a joke usually involves the violation of expectations [14]. By writing a paper about 6-7, I hope that I will have violated certain expectations about the content of an academic paper. That being said, not only is this SIGBOVIK, the conference where one is taught to expect the unexpected, I also quite literally publicly stated my intentions to write this paper. That definitely dampens the humor to some degree.

6-7 as a phenomenon isn't particularly funny either. It's funny to point out when it's being said unintentionally, but ultimately, unless you build your own joke on top of it over time, it is just a reference, reference being a superset of "self-reference" as Tom mentioned [14].

This paper really is just some math explanations with a bunch of different references tacked

[1] $e^{\pi\sqrt{163}}$ is better known as Ramanujan's constant.

on. I think that constitutes a paper funny enough to be worth submitting to SIGBOVIK. I hope you think the same.

3. Various Prime Properties

Well, wasn't that fun. 67 is a prime number, as this section's title implies. It also happens to fit within some of the various special categories of prime numbers, those being: Chen prime ($p + 2$ is prime or semiprime [15]), irregular prime (something about class numbers [16]), lucky prime (survives for a longer time in a sieve similar to Eratosthenes [17]), super prime (nth prime number where n is prime [18]), sexy prime (separated from adjacent primes by 6 [19]), and Pillai prime ("a prime number p for which there is an integer $n > 0$ such that the factorial of n is one less than a multiple of the prime, but the prime is not one more than a multiple of n" [20]) [21].

3.1. Applications

Once again, not much. Don't get me wrong, it's cool. But when the article for most of these is shorter than the article for *Action 52* [22], then you know there isn't much. For that matter, the Wikipedia article for 6-7 itself is longer [23][2].

4. Recognition of Other Funny Numbers

Before doing specific research for this paper, I was aware of various number memes, including those which preceded 6-7, and those which were spinoffs. Pre-6-7 memes include: 15, 21, 24, 25, 42, 69, and 420, while notable 6-7 spinoff memes include: 41, 61, 68, and 89.

After some minor searching on YouTube, I was able to find a video, helpfully titled *ALL Original Version Memes Number: (0-100)*. After reviewing the video, I am able to confirm the existence of number memes for all numbers 0 to 100 inclusive, and infinity [24]. TikTok user Andrew John Belovo IV has taken the idea beyond real numbers with "$\pm 2i\sqrt{19}$" [25], and into other mathematical areas with "arbitrary ϵ for which $\exists \delta > 0$ such that $0 < |x - a| < \delta \Rightarrow |f(x) - L| < \epsilon$" [26].

An XKCD comic covered the historical precedent of number memes, noting in particular "23 Skiddo", a phrase which became popular in the early 20th century, used almost exactly as 6-7 is now [27]. There are even reports of the same kind of dubious merch being sold that seems to be all too popular today: "Pennants and armbands at shore resorts, parks, and county fairs bore either [23] or the word 'Skiddoo'," [28].

5. Other "Nonsensical" Memes and Future Development

A good friend of mine brought up the possibility of 6-7 spinoffs going into other categories, with his specific example being "m-n" [29], which "means-nothing" (stated in the same tone of voice as 6-7) [30]. *Veggietales* had that episode set in the future with the randomly generated "weed-eater" and that also feels like the same kind of thing [31].

6. Conclusion

Well, there we go. As I write this it is March 18th, the extended deadline, and a third deadline has not been announced. There is, of course, a functionally unlimited breadth of topics I could have brought in and related to 6-7 but at some point one needs to decide to stop, so I am doing that now. I think I learned a decent amount about math in writing this paper, and I hope you've learned a decent amount by reading it. There really is a lot of interesting "fun" math out there which readers of this conference are no doubt already aware of.

If you liked this paper (or any of my previous ones), please do reach out. I am incredibly easy to find on the internet and would love to talk about the things I discussed here or computer science or anything really. Also, if you are

[2]Not sure how I got this far without citing it.

considering submitting a paper to SIGBOVIK, I can't recommend it enough. In an age where people seem to care less and less about writing skill, it's nice to have a space where you are encouraged to write about anything you want. Everyone (well, okay maybe not *everyone*) who submits to this conference is ultimately just a person who's passionate about what they do, and that's not something you can say about a lot of academia.

7. Acknowledgements

As always Tom Murphy [VI-]VII will receive a shoutout for his commitment to the intersection of theory and impractice. I'd also like to thank Wikipedia editors for doing their best to make the more complex math topics accessible. Thanks to Rosly; although her work never appeared in the paper, her attempts with "Styx Heaven" and "Sieges Even" will not be forgotten.

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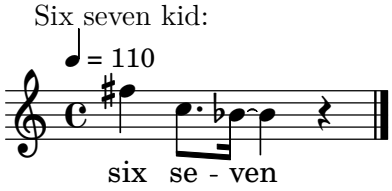
A. Recommended Pronunciation [32]

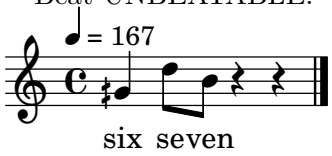
[3]

Six seven kid:



[33]

Beat UNBEATABLE:



[34]

B. Euler Diagram

Get yourself on a slide with Descartes, Hofstadter, and Tom7 to boost your own credibility [14].

[3] State of the art reviewing had to pre-render, but I did it all in-engine. Take that.