THE QUARK

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Ramanujan and the sum:

1+2+3+4+… =

By Colin Brown
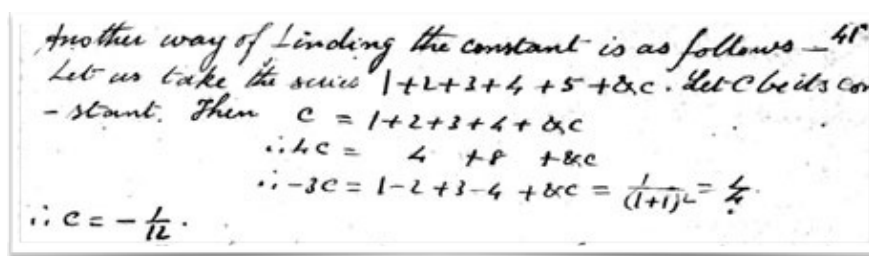
"I told him that the sum of an infinite number of terms of the series:
$1 + 2 + 3 + 4 + \cdots = -1/12$ *under my theory. If I tell you this you will at once point out to me the lunatic asylum as my goal."*
- Srinivasa Ramanujan [5]

The above image is an excerpt from the notebook of genius Indian mathematician Srinivasa Ramanujan[1]. His tendency to represent mathematically impressive concepts in remarkably simple terms may make what's being stated difficult to interpret. Shown here is an analysis of the sum of all natural numbers. (1+2+3+4+...) Puzzlingly, he seems to arrive at an absurd result. The sum of all natural numbers is equal to negative one over twelve.

$$1 + 2 + 3 + 4 + \cdots = -\frac{1}{12},$$

This apparent equality gained some public attention in 2014 when popular math focused YouTube channel Numberphile released a video[2] showing a recreation of Ramanujan's proof, which now has upwards of six million views. This unsurprisingly caused a small uproar among those who watched the video and had not previously

known about the result. This is understandable, it seems like complete nonsense to many with an understanding of mathematics. It defies our understanding of summation and natural numbers. This proof has a rich history however, and does represent a profound result. Before examining that, however, it helps to address a misunderstanding.

The apparent impossibility of this equality is a result of a lack of context. Most importantly, it is not an equality; the number on the right side of the equals sign does not represent the final value of the summation, which diverges, but a finite value that can be taken to represent the summation.[3] This value results from techniques such as Zeta Function Regularization, Cutoff Regularization, and Ramanujan Summation, all of which provide unique values to divergent sums that are not in truth the result of the sum, but rather unique values that may represent the sum.[4] Professor Edward Frenkel, a professor at University of California, Berkely, describes it the following way in an interview:

> *"Imagine this whole series as a huge lump ... what if there is a way ... a nice scalpel which will allow us to surgically remove infinity, and then keep kind of a finite part .... We will assign that finite part as the true answer to this infinite series." - Professor Edward Frenkel [3]*
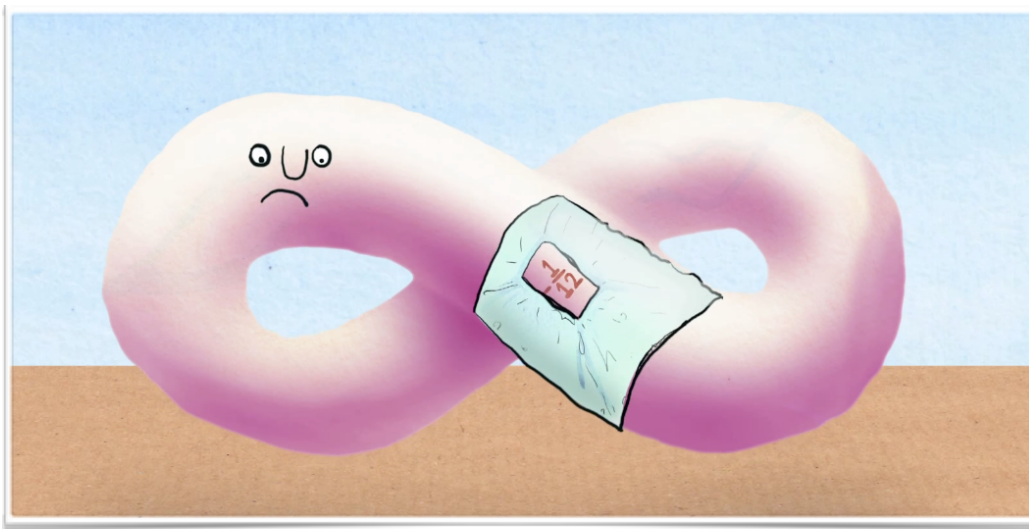
Ramanujan was by no means the first person to discover this result. It is believed that Swiss mathematician Leonhard Euler (1707-1783) may have discovered it within his work on infinite series. German mathematician Bernhard Riemann (1826-1886) also provided a method of formally proving the result through the use of the famous Riemann Zeta function.[3]

Surprisingly, this identity has seen usage in the realm of Physics. It is important to the calculation of forces resulting from the Casimir Effect, and it is this result that defines the number of dimensions in Bosonic String Theory.[6] This is not merely a mathematical curiosity, but something that is apparently fundamental to physical reality.

Attempting to explore the proofs and consequences of this identity is without a doubt beyond the scope of this newsletter, but I hope the introduction provided here will help guide readers in how to approach learning more about this profound result.

Want to make your own DIY Real-Time Oscilloscope with Arduino Uno for free?

Want to attend CUWiP? (Conference for Undergraduate Women in Physics)

Join Women in Physics for the second general meeting of the semester, to be held Friday, October 12th, in SCI 234 at 5:35pm. All are welcome!

Meeting topics:

- Public Speaking Workshop
- How to apply for CUWiP
- WiP Officer nominations
- DIY Real-Time Oscilloscope

To learn more visit TTUWiP.com or contact ttuwip@gmail.com

Attendees of the first Fall 2018 WiP meeting with Dr. Melanie Ungar

Sources:

[1] https://www.imsc.res.in/~rao/ramanujan/NoteBooks/NoteBook1/chapterVIII/page3.htm

[2] https://www.youtube.com/watch?v=w-I6XTVZXww

[3] https://www.youtube.com/watch?v=oOazb7IWzbA

[4] https://terrytao.wordpress.com/2010/04/10/the-euler-maclaurin-formula-bernoulli-numbers-the-zeta-function-and-real-variable-analytic-continuation/

[5] https://books.google.com/books/

[6] cecelia.physics.indiana.edu/journal/casimir_review.pdf

Professor Spotlight: Dr. Sung-Won Lee

By Ravyn Perez

Dr. Sung-Won Lee is native to South Korea and is a professor at Texas Tech University. He first came to Tech in 2006 and is an upper-level physics professor and interim chairman. Initially, Dr. Lee had aspirations to study at an engineering college and applied to physics departments as his last choice. Despite having a love for physics in high school, he felt drowned in physics due to his father being a physicist, trips to his father's lab on weekends, and the hundreds of physics books he grew up seeing as a child. This is why he wanted to study engineering, to get away from it. Ultimately, he accepted the offer to study physics to avoid the military.

In his sophomore year of college, his father gave him a book regarding why we study particle physics, the origin of the

universe, and how we can actually recreate the Big Bang artificially. This really caught his attention and was his initial exposure to building accelerators that can do just that. He went on to get his B.S. in physics from the Daegu University, Korea and his masters of science degree from the Kyungpook National University in particle physics and his PhD. at the University of Glasgow.

His research work with the company CERN was his first real exposure to particle physics. His first job was to spend 3 months there to copy and record all the data. While he didn't enjoy the routine of this job where day and night he does the same thing all day, he is starstruck by a man who walked up to him and asked what his job was, where he was from, and gave him words of encouragement. This man was Nobel prize winner Samuel C.C. Ting who discovering the J/psi meson particle which he remembers reading in his textbook his father gave him. This further encouraged his interest in particle physics. His next job as a researcher was at DESY Laboratory where he spent 2 and a half years where he focused on the physics analysis and hardware and safety. While there, he studied the theory of the photon having inner structure and its function.

His last research job was at a company called Fermilab where they maintained huge detector systems and his job was to collect data. The CDF experiment was what he found to be most important, but also the toughest. This was how he began to really get a big picture understanding of how the detectors work. This was impactful because Dr. Lee and his colleagues took part in the development of the theory of what is now Higgs field and evidence of Higgs Boson. Once he was through with this project he was stuck deciding if he wants to move bzack to Korea or get a job in the US as a professor. He took his chances and applied to a few places in the US first and received an offer with Texas Tech University. He considered Lubbock as his second hometown as he has a wife who he married shortly after working at Tech and a daughter.

> **"Everyone has talent. Some people discover their talent earlier on and some later than others, but if you never put in effort and work hard, you'll never discover what your own talent is."**
>
> *Dr. Sung-Won Lee*

(Art)stronauts

By: Nelson Mora

SpaceX is a company which was founded in 2002 with the goal of expanding human habitation to other planets as quickly as possible. Their goals even include planets that are in other solar systems. SpaceX pursues this goal because they believe it is part of the evolution of life on earth. Yusaku Maezawa will be SpaceX's first passenger. Maezawa will be on a spacecraft that is yet to be built which has been given the name BFR (Big Falcon Rocket). He will go to the moon to conduct a project he calls Dear Moon. In this project, he invites 6 to 8 artists from around the world, to go with him to the moon, since the BFR can carry multiple passengers. He has not invited any artists to go with him yet, nor has he said which artists

Astronomy Day

By Diane Ha

World-wide Astronomy Day is upon us! Join the Society of Physics and Dr. Robert Morehead for an exciting day full of fun and learning at the Moody Planetarium, located inside the Museum of Texas Tech.

Event Schedule:

*Free demonstrations and arts and crafts will be held from 12pm to 2pm! **$2 admission for each planetarium show below.***

- 11:30am - Astrobreaks

- 12:30pm - Secrets of the Cardboard Rocket

- 1:30pm - A special edition of "Astrobreaks" by Dr. Robert Morehead of the Department of Physics and Astronomy

- 2:30pm Saturn, the Ringed World

- 3:30 Legends of the Night Sky Orion/Perseus & Andromeda

** Please note that tickets go on sale 30 minutes before each show. No late sales/seating.

To learn more, visit https://www.depts.ttu.edu/museumttu/visit/planetarium.php

he's considering, but he is certain that he wants to take that many. Some examples of artists that Maezawa wants to take with him to the moon, are: Painters, Photographers, Musicians, Film Directors, Fashion Designers, and Architects. There is no specific date of take-off, but it is believed that Maezawa, and the artists who go with him, will go to the moon sometime in the year 2023, and they will be there for a week. While they're on the moon, Maezawa wants the artists to create works of art to inspire the people of earth. Maezawa was inspired to do this project when he asked himself, what if his favorite artists went to the moon. The price hasn't been specified yet, but that doesn't concern Maezawa since he's a billionaire. He owns a clothing company which gives him confidence in being able to afford this trip.

Yusaku Maezawa

Sources:

[7] https://www.spacex.com/about

[8] https://www.spacex.com/webcast

[9] https://www.forbes.com/sites/peterhimmelman/2018/09/20/with-artists-as-co-passengers-on-1st-spacex-ride-billionaire-maezawa-sends-message-of-possibility/#76f58796562e

Student Spotlight: David Palmore, President of the Society of Physics Students

By William Kariampuzha

Wherever David Palmore goes, he makes an impact.

A graduate of Sherman High School in Sherman, TX, David Palmore was a multisport athlete, once varsity football captain, a consistent honor roll student all four years, and an officer of 3D, an anti-bullying initiative at his school. He continued to make an impact when he stepped into Texas Tech. His freshman year he was nominated as the Model Student of the Month in Hulen Hall. He grew his Raider involvement by competing with the rugby team, then coaching the team after an injury ended his season.

Though he has cast a wide net of influence, David has found his niche in the Society of Physics Students. His first officer position was the treasurer, until he rose to the top as President. Into his new position, he brought a vision of a SPS that does interdisciplinary work to include its members and lift them to new horizons. He has done this by founding the STEM Dodgeball Tournament in which various Texas Tech math and science clubs compete outside of the classroom and learn from each other. He also contributed to the revamping of SPS by founding the fundraising committee, which utilizes membership dues to better provide for its members. One committee task in progress is the creation of the Graduate School Readiness Grant, a scholarship that is awarded to graduating seniors in SPS to help them pay for the GRE and graduate school fees. His goal is to eradicate the financial burden of his fellow undergraduate students.

Although we wish to keep him and his dashing good looks at Tech, David plans to graduate in May 2020 with a Bachelor of Science in Astrophysics with a minor in mathematics. After this, he plans to attend graduate school to pursue a PhD in Aerospace Engineering to work in Flight Integration for NASA or SpaceX.

To up and coming undergraduates who may be struggling to study physics, David has this for you — "not every course in this degree will come naturally. I, myself, failed calculus 2 the first time around. My advice is to **keep pushing through, no matter the problem, no matter the course**."

References:

[1] https://www.imsc.res.in/~rao/ramanujan/NoteBooks/NoteBook1/chapterVIII/page3.htm

[2] https://www.youtube.com/watch?v=w-I6XTVZXww

[3] https://www.youtube.com/watch?v=oOazb7IWzbA

[4] https://terrytao.wordpress.com/2010/04/10/the-euler-maclaurin-formula-bernoulli-numbers-the-zeta-function-and-real-variable-analytic-continuation/

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[7] https://www.spacex.com/about

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