# MASTER OF MACHINES

The Man Who Put Supercomputing On the Map

## Philip Emeagwali

**emeagwali.com**

*To my wife, Dale, for being so supportive and a wonderful partner in life.*

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## Master of Machines

### The Man Who Put Supercomputing on the Map

# Philip Emeagwali

The Reader's Digest described Philip Emeagwali as "smarter than Albert Einstein." He is ranked as the world's greatest living genius. He is listed in the top 20 greatest minds that ever lived.

Philip Emeagwali lived in refugee camps during the 1967-70 Nigerian-Biafran War and is in the Gallery of Prominent Refugees of the United Nations. He caught the attention of American scholars and was awarded a scholarship on September 10, 1973, to the United States.

In 1989, Philip Emeagwali rose to fame when he won a recognition described as the Nobel Prize of Supercomputing and made the news headlines for his invention of the first world's fastest computing across an Internet that's a global network of processors. That vital technology underpins every supercomputer and changed the way we look at the computer.

Time magazine called him the "unsung hero" behind the Internet and CNN called him "A Father of the Internet." House Beautiful magazine ranked his invention among nine important everyday things taken for granted. In a White House speech of August 26, 2000, then U.S. President Bill Clinton described Philip Emeagwali as "one of the great minds of the Information Age."

# 1ST LECTURE: THE DAYS OF MY FASTEST COMPUTING

**Broadcast 19 August 2021**

# MATHEMATICS MEETS TECHNOLOGY

*Using the Billion Slowest Processors to Solve the Most Difficult Problems*

My contribution of the world's fastest computing to mathematical knowledge made it possible to invent a new computer. And create new mathematics. In 1989, I was in the news for discovering how to harness the world's slowest processors. And use those processors to solve the most difficult problems at the crossroad where new mathematics, new physics, and the world's fastest computing intersect.

In algebra, the most difficult problem was to discover how to solve the largest system of equations arising when executing detailed computational fluid dynamics codes, such as global climate modeling or petroleum reservoir simulation.

And executing those codes across the millions of processors that outline and define a supercomputer. In the 1970s and 80s, my mathematical quest was to become the first person that could solve such initial-boundary value problems. And solve them across the slowest processors in the world.

At 8:15 in the morning of July 4, 1989, I discovered that the world's fastest computer can be built with the world's slowest

processors. And I invented the supercomputer technology and did so across the slowest processors in the world. That new supercomputer paved the way and became the precursor of the world's fastest computer that now computes with millions of ordinary processors.

Parallel supercomputing was my mathematical quest for how I can cross the new frontier of knowledge of how to solve an unsolved system of equations in algebra. My quest was to cross that frontier and conquer today's mathematical challenges. My quest was to solve previously unsolved problems and quickly compute the most compute-intensive problems in large-scale computational fluid dynamics, such as simulating the spread of contagious viruses inside Japan's Tokyo subway where 3.1 billion passengers a year are packed like sardines.

In 1989, it made the news headlines that an African supercomputer genius that worked alone in Los Alamos, New Mexico, USA, has invented how to solve the largest system of equations in algebra. And invented how to solve those systems by parallel supercomputing them, or solving many equations at once. And solving those equations across a new Internet that's a new global network of 65,536 coupled processors. I visualized my computing machinery as a small copy of the Internet.

## *Cracking the Code for the Largest System of Equations: My 1989 Story*

I was the African supercomputer scientist and the computational mathematician that was in the news in 1989. I was in the news for inventing how to solve the largest system of equations during the most important applications of algebra. One such application is in computational fluid dynamics. The poster girl of large-scale computational fluid dynamics is the supercomputer petroleum reservoir simulation that must be used to nail down the exact locations of crude oil and natural gas.

Such extremely fast calculations can only be executed **across** an ensemble of millions of processors that occupies the space of a soccer field. And that simulates an oil producing field that's up to 7.7 miles (or 12.4 kilometers) deep. An oil field is about the size of Abuja, **Nigeria**. The Agbami Oil Field of Nigeria was discovered in late **1998.** Agbami was Nigeria's second largest deep water oil field. Agbami is second to the Bonga Oil Field. Agbami Oil Field is located 4,900 feet (or 1.5 kilometers) away from the coastal shores of central Niger Delta. It has a peak oil production of 250,000 barrels per day.

Why is the supercomputer important to Nigeria? One in ten supercomputers were bought by the petroleum industry. And Nigeria is an oil-producing nation.

# UNLOCKING THE POWER OF SUPERCOMPUTERS

*Forecasting Weather and Reservoir Simulation*

The most powerful computer in the world costs the budget of a small nation. The fastest computer is the heavyweight champion in the world of petroleum technologies. The supercomputer is used to pinpoint deposits of crude oil and natural gas. Fastest computing is my contribution to modern algebra and to the petroleum industry.

I'm the subject of inventor reports because I invented how to execute the world's fastest calculations. And perform them **across** an ensemble of the slowest processors in the world. And solve the most compute-intensive problems at the crossroad where new mathematics, new physics, and the world's fastest computing intersect. I invented how to solve the most compute-intensive problems. And solve them **across** a new Internet that's a new global network of 65,536 coupled, off-the-shelf processors that shared nothing. And that each operated its operating system.

By 1986, I realized that the most difficult problem in petroleum reservoir simulation, namely, the solution of a parabolic system of partial **differential** equations was at its granite physical and mathematical cores an effort to forecast the

weather. But to forecast it **backwards** in time. This backward technique is called hindcasting. And is used to forecast, or rather to hindcast, the "weather." And hindcast, or re-forecast, up to 7.7 miles (or 12.4 kilometers) below the surface of the Earth. And hindcast it **across** an oil producing field that's up to twice the size of the state of Anambra, Nigeria.

Because I was both a **geologist** of the late 1970s and a **meteorologist** of the early 1980s, I could translate that compute-intensive problem. And translate it **across** physics, calculus, algebra, and computer science. And translate it from the primitive equations of meteorology to the nine **Philip Emeagwali** equations of mathematical geophysics.

This new field of study is described as the subsurface porous media multiphase fluid flow modelling executed **across** millions of off-the-shelf processors that were identical and coupled. In 1989, I could solve the most difficult problem arising in supercomputing. I solved it by deeply understanding and drawing on the mathematical metaphors between the extreme-scaled computational fluid dynamics problems in both meteorology and geology.
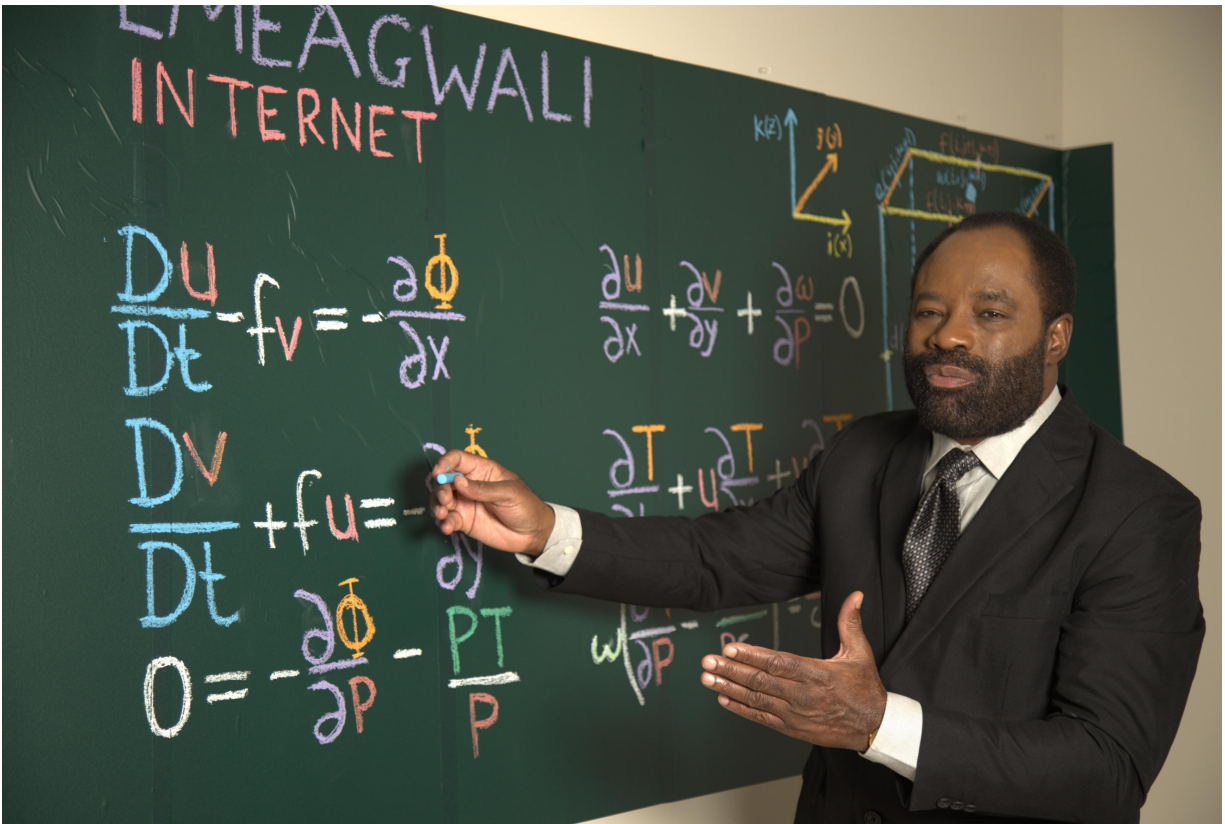
*Breaking the Speed Barrier: Crafting the Fastest Computers for Mathematicians*

My contributions to mathematics had their calculus and algebra roots on how I reformulated the hardest problem in subsurface geology. I reformulated that mathematical problem and did so in a meteorological context. Furthermore, I parallel processed that mathematical problem. And I did so across a then world-record ensemble of 65,536 processors. Not only that, I visualized those processors as outlining and defining a small Internet. And as tightly circumscribing a globe and encircling that globe in the manner computers encircle the Earth.

*Shattering Expectations by Changing the Way Mathematicians Solve Tough Problems*

My 1989 discovery changed the way mathematicians solve their most compute-intensive problems. In my new way, the most difficult problems in physics, mathematics, and computer science are solved **across** an ensemble of millions of processors, instead of within one processor as was done in the old way.

The toughest problems in mathematics are solved on supercomputers purchased for the Nigerian petroleum industry. The prototypical most difficult problem in supercomputing was to compute at the fastest speeds the motions of crude oil, injected water, and natural gas that were flowing **across** an oil producing field that's up to 7.7 miles (or 12.4 kilometers) deep.

An oil field is about the size of my hometown of Onitsha, **Nigeria**. The Bonga Oil Field is located off the Nigerian coast and 75 miles [or 121 kilometers] southwest of the Niger Delta. The Bonga Oil Field was underneath an average water depth of 3,300 feet [or one kilometer] and covers 60 square kilometers. And produces both crude oil and natural gas. The Bonga Oil Field began production in November 2005. And was projected to be abandoned in the year **2022**.

In the **1950**s, **60**s, and **70**s, mathematical physics textbooks classified the governing system of coupled, nonlinear, time-dependent, three-dimensional, and state-of-the-art partial _**differential**_ equations as parabolic. Often, when parabolic partial _**differential**_ equations are discretized to yield a system of partial _**difference**_ equations, the resulting system of equations of computational linear algebra is tridiagonal. Its associated tridiagonal matrix has nonzero elements on the main diagonal and on the two diagonals below and above the main diagonal.

## My Computing at the Speed of Thought

Why was my contributions to mathematics in the news in 1989? My contribution to mathematics **was this**: In the **1980**s, I changed the way we looked at the calculus and the algebra behind the compute-intensive simulations of the motions of crude oil and natural gas that were buried up to 7.7 miles (or 12.4 kilometers) deep. And buried **across** an oil field that's about the size of a town.

My mathematical discovery was that the world's fastest computer can be built with the world's slowest processors. My invention was the cover story of top mathematics publications, including the May **1990** issue of the _SIAM News_ which was the

flagship publication of the Society for Industrial and Applied Mathematics.

## *New Way of Thinking: Solving the Unsolvable in Algebra*

I'm the subject of school essays on famous mathematicians because I changed the way mathematicians solve their most compute-intensive problems in algebra. My contribution to the mathematical knowledge and supercomputer technology used to nail down the exact locations of crude oil and natural gas **is this**: I **paradigm shifted** from a parabolic system to a hyperbolic system of partial differential equations that governs that initial-boundary value problem.

And I **paradigm shifted** again from **tridiagonal** to **diagonal** system of equations of computational linear algebra from the parabolic and hyperbolic systems, respectively. I invented the system of equations of computational linear algebra that must be used to **recover** otherwise **unrecoverable** crude oil and natural gas.

In 20ᵗʰ century algebra, such systems were most often **tridiagonal**. Such **tridiagonal** systems are unsolvable in parallel. Or impossible to solve by dividing each into a million, or even a billion, lesser compute-intensive problems that can be mapped

onto as many processors and then solved with a **one-to-one** correspondence. And solved **at once**, or in parallel.

Because I was computing and communicating **across** a global network of 65,536 processors, I saw computational mathematics **differently**. Because I saw mathematics **differently**, I thought **differently** and invented **differently**.

# BREAKING THE BARRIERS OF MATH

*The Nine Philip Emeagwali Equations*

Why did I invent the nine Philip **Emeagwali** equations? My original derivations of the nine **Emeagwali** equations are lengthy. However, they're fully described in my YouTube channel, named "**Emeagwali**." In essence, my point of departures from the mathematical derivations of Darcy's equations, that govern subsurface geophysical fluid dynamics, were that I accounted for both the temporal and convective inertial forces. I've posted the mathematical details **across** my one thousand videos that I've also posted on YouTube. For clarity, I detailed my mathematical derivations in close captioned prose.

My mathematical quest was to discover how to solve the **differential** initial-boundary value problem, not for how to solve the **algebraic** discrete problem from that initial-boundary value problem. My quest wasn't **for** how to solve the initial-boundary value problem and **solve it** as an applied mathematician who **solved it** on his blackboard. That quest for an extremely fast computer was for how to solve the never-before-solved largest-scaled problems in computational linear algebra. And solve them

as a modern computational mathematician who is sitting astride his global network of sixty-four binary thousand motherboards. Each motherboard was a computational metaphor for his as many, or 65,536, blackboards.

I invented a system of nine partial **differential** equations of calculus. And then invented my nine partial **<u>difference</u>** algorithms, or the complete step-by-step instructions each of my 65,536 processors must execute as the condition to solving the difficult mathematical problem. And solving it at the world's fastest speed that made the news in 1989.

I used my new algorithms to **discretize** my system of partial **differential** equations which, in turn, yielded my system of 24 million equations of computational linear algebra. Those were the longest equations in the mathematics of 1989. With my new algorithms, those equations became **diagonal**, instead of **tridiagonal**. It's impossible for my new system of 24 million diagonal equations of algebra and the old system of 24 million tridiagonal equations of algebra to be mathematically equivalent.

## *Unveiling Identical Math Problems: Cloning Solutions*

I visualized my problem as identical twin problems of algebra. The diagonal and the tridiagonal systems of equations of

computational linear algebra arose from different initial-boundary value problems with **the same** boundary condition, **the same** initial condition, and **the same** mathematical and physical domains. However, each initial-boundary value problem had a **different** governing system of partial **differential** equations at the frontier of calculus.

The diagonal and the tridiagonal systems of equations of computational linear algebra are equivalent in their physical essences. And they're equivalent in the physical sense that both arose from a **hyperbolic** and a **parabolic** system of coupled, nonlinear, time-dependent, three-dimensional, and state-of-the-art partial **differential** equations, respectively. Both systems of partial **differential** equations of calculus encoded the same set of laws of physics.

My new diagonal and the old tridiagonal systems of equations of computational linear algebra approximated the same difficult mathematical problem of extreme-scale computational physics. My new diagonal and the old tridiagonal systems of equations of computational linear algebra are as different as identical twins from the same **egg** and **sperm** and from the same **genetic materials**.

Just as identical twins are clones, my new diagonal and the old tridiagonal systems of equations of computational linear algebra were clones. They're **not** algebraically equivalent. But

they arose from the same difficult mathematical problem of extreme-scale computational physics. Metaphorically speaking, they arose from the same **egg** and **sperm**. Scientifically speaking, they arose from the same set of laws of physics.
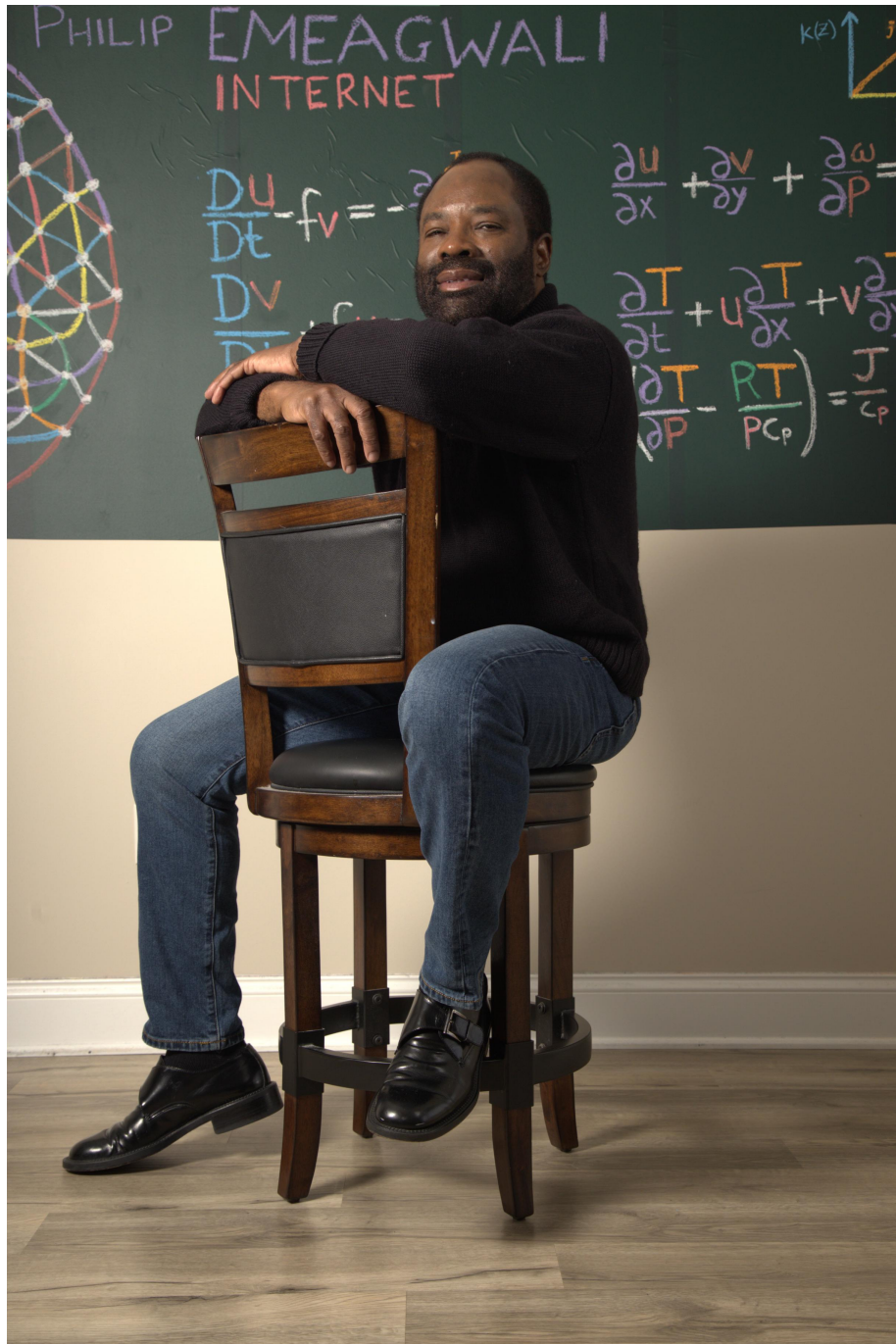
# *Math Magician's Unexpected World Record*

My contribution to mathematics is this: I solved one of the most compute-intensive mathematics problems. And I solved it at the fastest computer speed executed across an ensemble of the slowest processors in the world.

My **invention** of fastest computing which occurred on the Fourth of July **1989** changed the way mathematicians solve the most compute-intensive problems in algebra. The cover stories of mathematics news journals read by leading mathematicians celebrated my mathematical discovery as a breakthrough that makes it possible for high-performance computational mathematicians to achieve speeds in supercomputing previously considered impossible.

In 1989, mathematicians celebrated my discovery of the fastest computing. And did so because it heralded the end of their old arithmetic paradigm of solving one compute-intensive problem **at a time.**

And it marked the beginning of the new paradigm of **concurrently** solving millions of sets of compute-intensive problems. And solving them **at once.** On the Fourth of July **1989**, I achieved a supercomputer breakthrough. I used the 65,536 slowest processors in the world to reduce 65,536 days, or

180 years, of **time-to-solution** to merely one day of **time-to-solution**.

Furthermore, I discovered that the most compute-intensive problems in the algebra that, in turn, **arose** from calculus could be solved **across** a new Internet. Not only that, I invented that new Internet as a new global network of sixty-four binary thousand processors that were coupled. Each processor had its dedicated memory that shared nothing, but were in dialogue with each other.

My high-performance computing experiment which I conducted **across** a new Internet that's a new global network of 65,536 processors led to my discovery that elucidated why the world's fastest computer must be powered by millions of processors.

The reason my discovery of how to execute the world's fastest computing was in the June 20, 1990, issue of *The Wall Street Journal* was because it opened the door to the fastest supercomputers that were powered by over ten million processors.

*Reshaping the Oil and Gas Landscape with*

*Supercomputing*

I discovered how the oil and gas industry now harnesses the fastest computing from the slowest processors. And do so to nail down the locations of subterranean hydrocarbons. My discovery that millions of processors can be used to solve the most compute-intensive problems is the new knowledge used throughout the petroleum industry. It's the most critical technology now used to pinpoint deposits of crude oil and natural gas and used to recover them. It's used from the producing oil fields of Nigeria to the oil fields of Angola.

I used the largest system of equations of algebra that defined the most compute-intensive problems in physics as the backdrop for my experiments **across** my ensemble of 65,536 processors. I used those equations as my supercomputer testbeds. In the **1970**s and **80**s, fastest computing **across** slowest processors existed only in the world of science fiction.

My contribution to computer science was that I challenged the established truth and turned that science fiction to reality. That truth was the widely held belief that the slowest processors in the world cannot compute together. And do so to solve the most compute-intensive problems in algebra and in extreme-scale computational physics. And solve them at the fastest recorded supercomputer speeds.

The recognitions which I received from the supercomputing community, in 198**9** and later, was the first time such **skepticism**

over parallel supercomputing was overcome. In the **1970**s and **80**s, 25,000 supercomputer scientists tried to parallel process and do so **across** processors and computers. They gave up. They dismissed my attempts to solve the most difficult problems—via parallel processing—as **impossible**. I proved them wrong.

# THE 'SPEED BARRIER' SHATTERED

## *Parallel Processing Unites the Fastest and Slowest Computers*

In an often-cited paper published between April 18 to 20, **1967**, the IBM supercomputer designer, **Gene Amdahl,** formulated **Amdahl's Law**. Briefly, **Amdahl's Law** predicted that supercomputing **across** the slowest processors will forever remain an enormous waste of everybody's time. **Seymour Cray** designed seven in ten supercomputers sold in the 1970s and 80s. **Seymour Cray** agreed with **Gene Amdahl**.

Using the chicken as his metaphor for the slowest processor and the ox for the fastest processor, **Seymour Cray** asked the supercomputing community his famous question: "If you were plowing a field, which would you rather use? Two strong oxen or 1024 chickens?"

Regarding the ox versus a billion-chicken debate, I visualized the Grand Challenge Problem of supercomputing as breakable and chopped up into one billion less-challenging problems, each akin to a few weed seeds in a large field. My theory was that a billion hungry chickens can eat up a thousand billion weed seeds and eat them faster than one hungry ox.

Parallel computing is a century-old theory that existed in the realm of science fiction. My contribution to computer science made the news because my invention of the first supercomputing across the world's slowest computers turned that science fiction to reality.

On the Fourth of July 1989, the century-old theory—of harnessing 64,000 human computers—became timeless and new again. It was never old. When I came of age, in the 1970s, the *Computer World* was the mouthpiece of the information technology industry. A state-of-the-art survey published in the June 14, 1976, issue of the *Computer World*, quoted the leaders of thought in the world of supercomputers as unanimously agreeing that harnessing thousands of processors will be too "large and clumsy."

The title of that *Computer World* article summed up the skepticism towards parallel processing and my later discovery of the world's fastest computing across the world's slowest processors. The pessimism was embedded into the title of that article, which was: "Research in Parallel Processing Questioned as 'Waste of Time.'"
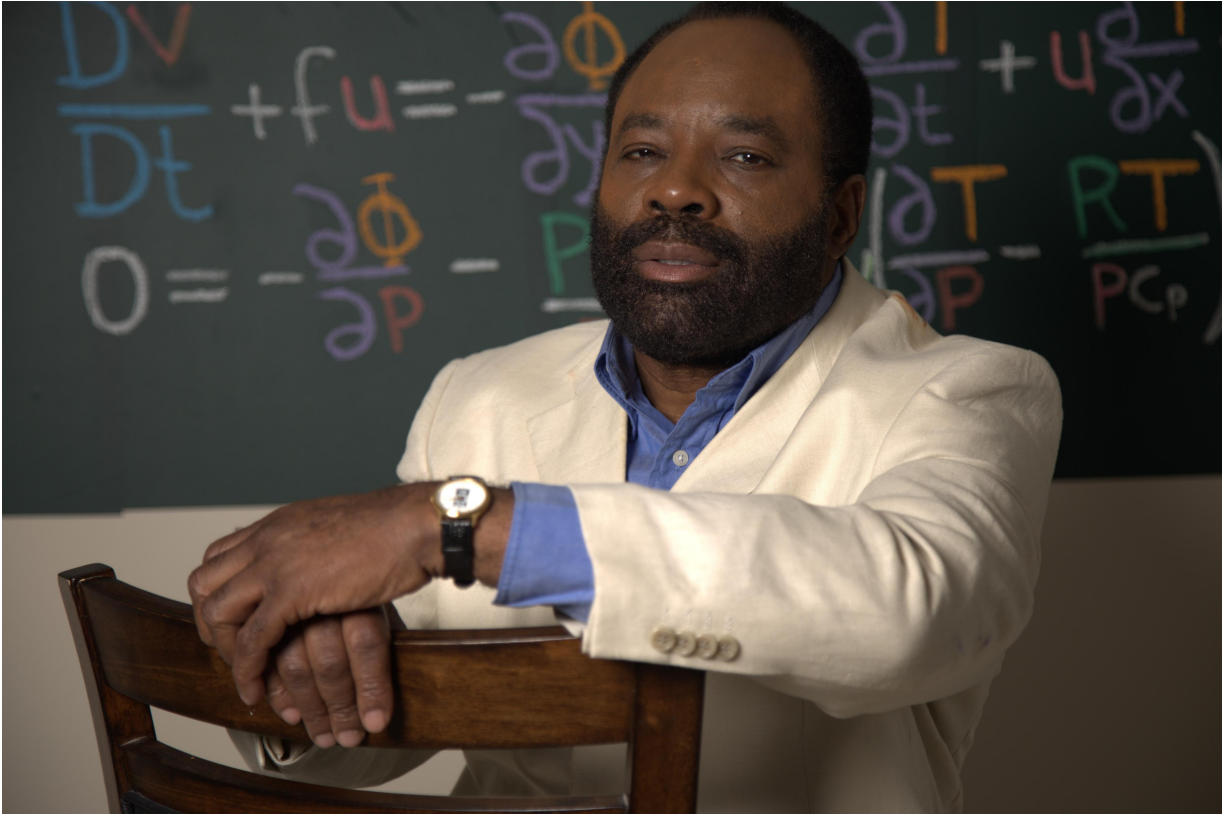
# BEYOND THE BINARY

*A Billion Times Faster: Computing with the Slowest Processors and Changing the Way We Look at Computers*

My discovery made the news because it was computing's equivalent of breaking the sound barrier to create a sonic boom. Before my discovery, fastest computing across slowest processors was an intellectual barrier that no human dared to cross. I was in the news because I was the first person to cross that intellectual barrier. I was the first person to scale the pinnacle known as the world's fastest computing.

On July 4, 1989, I became the first person to plant his country's flag in the then unknown territory of the supercomputer, as it's known today and as it's expected to be known tomorrow. I used 65,536 coupled processors to demonstrate how a mammoth supercomputer can be built from a billion processors. I discovered how harnessing up to a billion processors will enable the world's fastest computer to have the horsepower it will need to address the grand challenges of the scientific world.

I researched as a lone wolf because my supercomputing milestone was believed to be unachievable. Parallel processing powers every supercomputer manufactured today. The supercomputer is to science what the microscope is to biology.

My scientific discovery, which occurred on July 4, **1989,** was that the world's slowest processors can be used to solve the most compute-intensive problems in science, engineering, and medicine. My discovery of the central essence of the world's fastest computers made the news headlines because it changed the way we look at the modern computer. I discovered how to reduce 180 years of **time-to-solution** of the most difficult problems in large-scale algebra and computational fluid dynamics and how to reduce that time to one day of **time-to-solution.**

Philip Emeagwali returning from the soccer field and with his son, Ijeoma, at 1781 Cram Circle, Ann Arbor, Michigan, early Summer 1991.

In the 19**70**s and **80**s, I was mocked and ridiculed by vector supercomputer scientists and offhandedly dismissed because I claimed to have discovered how to reduce the **times-to-solution** of the most compute-intensive problems—such as the high-stake global climate models—

and reduce them by a factor of one billion **across** a new Internet that's a new global network of one billion processors that shared nothing. I was mocked for claiming my discovery of the world's fastest computing and claiming it when it was considered impossible to reduce those **times-to-solution** and do so by a factor of eight.

When confronted with such a compute-intensive problem, the vector supercomputing community joined ranks and tore holes in my then unsubstantiated theory. I theorized that the slowest processors could be harnessed and used to compute faster than the fastest supercomputer. My unorthodox approach to solving compute-intensive problems is called parallel supercomputing. Until my experiment of July 4, 1989, the parallel computer was not a supercomputer. It was then a million times slower than the supercomputer.

Ijeoma Emeagwali with his parents, Philip and Dale, at his first birthday party, 1781 Cram Circle, Number 7, Ann Arbor, Michigan, June 15, 1991.

In 1989 and in [the University of Michigan] Ann Arbor, Michigan, my character was maligned because I was conducting research on parallel supercomputers, a technology then dismissed as pseudoscience. I distributed six copies of my 1,057-page supercomputer report to scientists in [University of Michigan] Ann Arbor, Michigan. All six copies were thrown into the wastebasket.

To their surprise, a few weeks later, it made the news headlines that I had won the equivalent of the Nobel Prize in supercomputing. I won that prestigious prize for my

supercomputer invention which I fully described in my 1,057-page research report that they trashed into the wastebaskets of [the University of Michigan] Ann Arbor, Michigan.

After I won what was referred to as the Nobel Prize of Supercomputing, in 1989, the intellectual fireworks exploded. I didn't kill any person. Yet, I was subjected to a Galileo trial that was computing's equivalent to the O.J. Simpson trial.

If they were to accept my discovery they must forget many things they've learned, such as their belief in white intellectual supremacy. I solved the most difficult problem at the crossroad where new mathematics, new physics, and the world's fastest computing intersected. That accomplishment was the reason I was compared to the likes of Albert Einstein, Pythagoras, and Euclid.

In retrospect and for racial and intellectual reasons, I was not taken seriously as a Black mathematician who was equally at home in physics and computer science. I was confident because, as far as I knew, I was the only person in the world that devoted almost the entire decades of the 1970s and 80s to supercomputing across processors. I acquired the specific sets of skills and knowledge within mathematics, physics, and computer science that, in turn, would have enabled me to solve the most difficult problems in supercomputing.

**First**, I was Black and African and, therefore, grossly underrated with respect to Albert Einstein. **Second**, I was a lone and unsalaried supercomputer scientist whose research was grossly undervalued by both the funding agencies and the prize committees. They automatically rejected any submission from a Black African scientist. **Third**, I was misperceived as only a one-

dimensional mathematician or physicist, never as a three-dimensional polymath, or a triple threat that was also at home in computer science. **Fourth**, it was not widely known that I had been continuously supercomputing, since June 20, 1974, on one of the world's fastest computers

that was at 1800 SW Campus Way, Corvallis, Oregon, USA. **Fifth**, I was also trained as an astronomer, meteorologist, and geologist.



Philip Emeagwali, near the Computer Center, 1800 SW Campus Way, Corvallis, Oregon, where I began supercomputing on June 20, 1974, circa late July 1975.

Therefore, I was not timid about **crossing** disciplinary boundaries and doing so when pursuing the elusive answer to the biggest question in supercomputing. That question **was this**: How do we compute fastest with the slowest processors?

In supercomputing, the most compute-intensive problem must be breakable into a billion pieces that can be solved **at once.** And solved across a billion processors that each was self-contained and shared nothing. Solving the most difficult problem

across the world's fastest computer is akin to putting a jigsaw-puzzle, with a billion pieces, together.

# ACHIEVING THE UNTHINKABLE WORLD'S FASTEST COMPUTING

My invention of how to compute in parallel—or compute many things at once—was mentioned in the June 20, 1990, issue of *The Wall Street Journal*. It took me the prior sixteen years to discover how and why computing across the slowest processors makes the fastest computers fastest. My discovery opened the door that elevated the parallel computer to a new supercomputer that's up to a billion-fold faster, and that's used to solve the largest system of equations in many fields. Such Grand Challenge Problems range from computational fluid dynamics to computational medicine, such as simulating the spread of contagious viruses across Onitsha market where social distancing rules are not enforced.

In the 1980s, there were 25,000 computational mathematicians who also desired to know how and why a multitude of processors makes the slowest computers faster and makes the world's fastest computer fastest. The reason those mathematicians, gave up on massively parallel processing was because their textbook authors warned them that supercomputing

with up to a billion processors will forever remain an enormous waste of everybody's time.

If any of those mathematicians or physicists or computer scientists had the knowledge that I had, they would have been famous for solving the most difficult problem in supercomputing that I solved in 1989 and that made the news headlines.

## *Unveiling the Secrets of Computing and Rewriting the Rules*

Because everybody **ridiculed** and **rejected** the theory of solving many problems **at once**, parallel supercomputing was **abandoned.** That was how I became the lone full-time programmer of sixteen of the most massively parallel supercomputers ever built.

Today, the most powerful supercomputer hosts up to ten thousand programmers. What differentiates I and the other 25,000 vector supercomputer programmers of the **1980**s **were these**: I **invented** how to harness an ensemble of 65,536 off-the-shelf processors that were coupled and that shared nothing.

In **1989**, it made the news headlines that **an African supercomputer genius in the USA** had invented how to harness 65,536 processors. And invented how to use them to solve the most compute-intensive problems, called Grand Challenges.

Such problems arise while addressing some of the world's biggest problems, such as simulating the spread of Covid-19.

My invention opened the door to the technique of **parallel** and **distributed** algorithms and the companion technology of the **massively parallel** supercomputer. Parallel computing is the core knowledge that makes the **impossible**-to-solve **possible**-to-solve. And makes it possible to solve up to a billion mathematical problems **at once**. I was that African supercomputer scientist in the news in 198**9**.

*Solving Tough Math on the Slowest Computers:*

*Achieving the Impossible!*

The grand challenge of computing was to be the first person to solve the most difficult problem. And solve them at the world's fastest speeds. But solve them **across** the world's slowest processors. A reason it was called a Grand Challenge Problem was that the 25,000 vector supercomputer scientists, of the **1980**s and earlier, couldn't solve it. The reason vector supercomputer scientists couldn't **experimentally invent** fastest computing **across** the slowest processors was that they were merely reading about how it's impossible to harness 65,536 processors.

In the **1980**s, it was believed that it will forever remain impossible to harness millions of processors. And use them to cooperatively solve the most compute-intensive problems at the frontiers of knowledge in science, engineering, and medicine. Those 25,000 naysayers had the opportunity I had to solve the most compute-intensive problems which were central to supercomputing.

All they needed was the **brain power**. Each of those 25,000 vector supercomputer scientists knew that the **invention** of supercomputing **across** the slowest processors will be akin to discovering a **gold mine**. My contribution to the development of the supercomputer is the reason I'm the subject of school essays on "Inventors and their Inventions."

Twelve-year-olds often ask for pictures of my son (Ijeoma), my mother (Iyanma Agatha Emeagwali), and me. Photo taken in Monkton, Maryland, USA, (October 30, 2006).

# 2ND LECTURE: THE CODE WARRIOR



**Broadcast 19 August 2021**

**https://youtu.be/GcV14ZCdM5w**

# THE FIRST SUPERCOMPUTER

In 1989, I was in the news because I contributed the world's fastest computing to mathematical knowledge. That contribution changed the way mathematicians solve some of their most difficult problems. In their old way, the solution of the most difficult problem in computational mathematics was unsuccessfully tackled on the blackboard or one processor. In my new way, such problems are solved across up to a billion processors.

On July 4, 1989, I became the first person to cross the boundary of human knowledge of the world's fastest computing **across** the world's slowest processors. Those processors encircled a hyper-globe in the sixteenth dimensional hyperspace and did so in the manner the Internet encircles planet Earth. That was how I invented the first Internet that is a global network of 65,536 processors.

What is Philip **Emeagwali** known for? I discovered how to combine computers into a supercomputer that's an Internet. That discovery is like a light from an ancient sky. I'm the only father of the Internet that invented an Internet.

The supercomputer of today is radically different from those of the 1980s and earlier. Back then, supercomputers were

powered by only one processor. Each was the size of a refrigerator. And it costs up to forty million dollars each. The world's fastest computer, of today, can be powered by up to one billion processors. It occupies the footprint of a football field. And it costs forty percent more than the mile-long Second Niger Bridge in Nigeria.

I invented the world's fastest computing, as we know it today. In **1989**, I was in the news for discovering that the slowest processors could be used to solve the biggest problems. And find their answers at the fastest speeds. The fastest computer is why you know the weather before going outside.

## Computing the Unimaginable-to-Compute: How Coronavirus Spreads

The reason I was in the news for my contributions to fastest computing wa**s this**: I discovered that some compute-intensive problems that were impossible to solve with one processor could be solved across an ensemble of up to a billion processors. That's how the supercomputer is used to track how the coronavirus disease spreads. That was the audacity of my world's fastest computing that occurred on July 4, 1989, and that made the news headlines.

The inspiration that led to my scientific discovery of how and why using a thousand processors makes the new supercomputer the **fastest** came from my mathematical investigations of the rates of **error growths** that occur while solving the largest systems of equations in algebra.

Error growths occur while executing the most compute-intensive set of floating-point operations of arithmetic. Floating-point operations **arose from** finite difference equations of computational linear algebra. Finite difference approximations **arose from** discrete approximations of partial **differential** equations that govern initial-boundary value problems arising at the frontier of calculus.

My inspiration to compute at the fastest recorded speeds **arose from** the need to execute the most compute-intensive mathematical operations. Such operations **arose from** the need to solve the largest system of equations of algebra. Such large-scale algebra **arose from** the need to discretize the partial **differential** equation at the frontier of calculus. Such abstract calculus **arose from** the need to encode some laws of physics and chemistry that govern the twenty most difficult problems in supercomputing.

The poster child of the most difficult problems in supercomputing is the extreme-scaled computational fluid dynamics codes that must be used to simulate the spread of a once-in-a-century global pandemic. The supercomputer must be

used to simulate the spread of virus droplets **among** the billions upon billions of train passengers around the world that are packed like sardines.

The fastest computer is used to simulate ways of stopping the spread of contagious viruses. The world's fastest computer is used to solve unsolved problems that are important to society.

## *Achieving Optimal Performance: Guaranteeing Convergence, Consistency, and Stability of My Algorithms*

I began supercomputing on June 20, 1974, in Corvallis, Oregon, USA. At that time, I described myself as a mathematician who is a number theorist. My high-performance computing started as a hobby, not a serious profession.

Back in Onitsha, Nigeria, of the early 1970s, I conducted independent research on "Pythagorean triplets." Each triplet was an integer solution of the equation A-squared plus B-squared equals C-squared. In the 1970s, I gradually shifted my research interest from number theory of pure mathematics to numerical analysis of applied mathematics to large-scale computational fluid dynamics.

Philip Emeagwali (in dark shirt and 2nd from right of last row with five students) in a photo call of Saint Charles House of Christ the King College, Onitsha, Nigeria,, where he was only known by his nickname "Calculus." Bishop Francis Arinze lived in the rear building, early 1971.

And, finally, to massively parallel supercomputing that's executed **across** up to a billion processors. I visualized my 65,536 processors as encircling a hypersphere in sixteen-dimensional hyperspace. And encircling it in the manner the Internet encircles the Earth.

The mathematical fields of **number theory** and **numerical analysis** are almost diametrically opposite. Number theory is abstract and is investigated on the blackboard. On the other hand, numerical analysis is applied and investigated on the motherboard. Number theory demands precise solutions. And is

used to invent encryption algorithms. In contrast, numerical analysis accepts approximate solutions of partial **difference** algorithms arising in computational physics.

Since the equivalence theorem was discovered, in 1954, research computational mathematicians investigating the discrete solutions
of partial **differential** equations, indirectly, proved convergence. And did so by only proving consistency and stability.



Philip Emeagwali (grandson-in-law), Pa Charles Baird, Dale Emeagwali (granddaughter), Ma Mamie Baird, 1915 East-West Highway, Apt. 303, Silver Spring, Maryland, circa July 1984.

By convergence, I mean that as my grid spacing tends to zero my solution of my system of partial **difference** equations converges to the exact solution of my system of partial **differential** equations that I discretized.

In 198**1** and a few years after, and in College Park, Maryland, I did extensive **consistency** and **stability analyses**. That is, I theoretically and experimentally investigated the rates of propagation of numerical errors that **arise** when the algebraic computations advance from one time step of finite **difference** approximations to the next time step. I knew in advance that my approximations to the originating partial **differential** equations are stable, if and only if, the errors introduced at any time-step were not amplified at later time steps but were reduced at subsequent time steps.

In my stability proofs, I computed for the norms of the solution. The theoretical proof of the stability of finite difference approximations of real-world partial **differential** equations are impossible to prove. Instead, I proved the stability of a "close" problem. And then confirmed the stability of the complete partial **difference** approximations. And do so by coding and testing the numerical solutions.

From my linearized **stability analyses,** I mathematically discovered that I'll do fewer computations if I started from first principles. Or start from the Second Law of Motion in physics

textbooks. And do so to re-derive the governing system of coupled, nonlinear, time-dependent, three-dimensional, and state-of-the-art partial **differential** equations of calculus. Such equations govern the flows of crude oil, injected water, and natural gas that's often flowing up to 7.7 miles (or 12.4 kilometers) deep and **across** an oil producing field that's about the size of Baltimore, **Maryland**.

I mathematically discovered that when I include the temporal and the convective inertial forces then the governing partial **differential** equations become hyperbolic, rather than parabolic. From my linearized **stability analyses**, mathematically discovered that I'll do fewer computations if the discretizations, or reduction from infinite to finite, of the governing system of partial **differential** equations to an approximating system of partial **difference** equations were explicit, rather than implicit.

## *Breaking Through the Restrictions: Exploring the Possibilities Beyond Darcy's and Amdahl's Laws*

In 1981, my big question was to figure out how to bypass the two vexing limits in physics and computer science that were known as Darcy's Law and Amdahl's Law, respectively. From my linearized **stability analyses,** I mathematically discovered how to bypass the constraint that was imposed by Darcy's Law. That constraint limited the execution times of computational fluid dynamics codes that were governed by that Darcy's Law.

And bypassed the perceived Amdahl's Law limit of the maximum speed increase of a factor of eight.

That was how I addressed the vexing limit of Darcy's Law that could make my world's fastest computing less efficient and more compute-intensive. That was how I addressed the vexing limit of Amdahl's Law on the speedups **across** the millions of processors powering the world's fastest computer.

From my linearized **stability analyses,** I learned that my **diagonal** system of equations of algebra **arose from** conditionally stable and explicit finite difference algorithms while my **tridiagonal** system of equations of algebra **arose from** unconditionally stable implicit finite difference algorithms. In the practical terms of large-scale, high-performance supercomputing, implicit methods allowed larger time steps which are more efficient. But implicit methods only allow sequential calculations which are slower to compute. I discovered that implicit methods that yield a system of tridiagonal equations of algebra yield longer **times-to-solution** than explicit methods that yield a system of diagonal equations of algebra.

I discovered that it's **possible** to solve the system of diagonal equations of algebra and solve them in parallel, or by solving them at once at 65,536 processors. Or to at once solve the diagonal system and solve them **across** my new Internet.

I invented that new Internet as my new global network of 65,536 processors that were identical and equal distances **apart**. As correctly explained in textbooks on computational linear algebra, it's impossible to directly reformulate a system of **tridiagonal** equations and reformulate that system into an equivalent diagonal system.

That was my motivation for reformulating both systems of diagonal and **tridiagonal** equations. And reformulating them to solve the same initial-boundary value problem, particularly those in large-scale, high-fidelity computational fluid dynamics, such as petroleum reservoir simulations.

## *Unlocking the Unimaginable: How to Make the Impossible, Computable*

In the **1970**s and **80**s, my dream of discovering the world's fastest computing **across** the world's slowest processors was ridiculed as wonderfully useless. The reason I conducted my world's fastest computing research alone was because supercomputing **across** the slowest processors was mocked and dismissed as a **vacuous gimmick**.

In the 19**70**s and **80**s, the conventional wisdom in supercomputing **was this**: "Solve one problem **at a time** and solve that problem **as** fast **as** possible." In an article dated September 2, **1985,** the president of Cray Research Incorporated,

the company that then manufactured seven in ten supercomputers, described his company's attempt to harness 64 processors as "more than we bargained for."

My mathematical quest began as an abstract speculation of a lone mathematician, in 1974, Corvallis, Oregon, USA. That speculation was on the pure logic of differential calculus and in the compute-intensiveness of large-scale algebra.
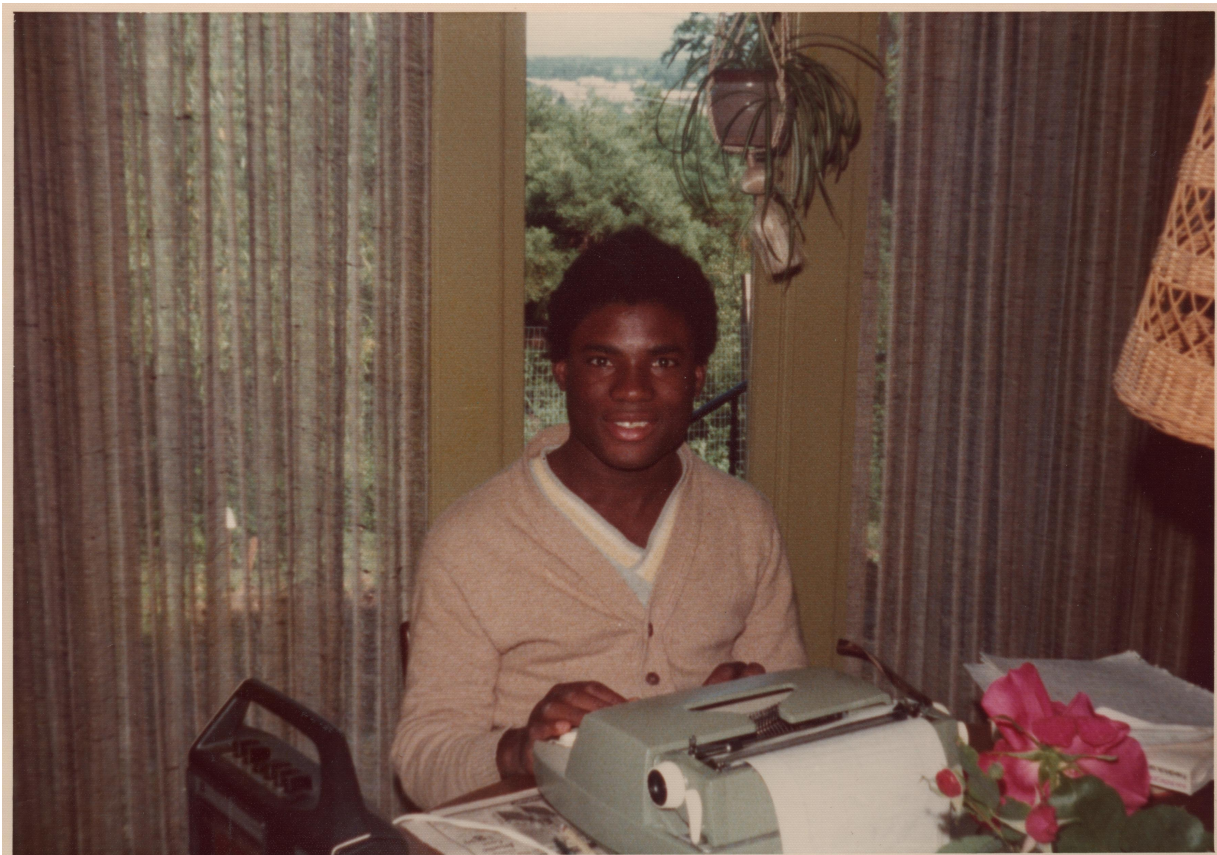


Philip Emeagwali, 15 Edgewood Way, Corvallis, Oregon, early June 1975.

# REIMAGINING THE SUPERCOMPUTER SOLVING PROBLEMS IN TANDEM

The precondition to discovering my world's fastest computing was that I, first and foremost, also discover how to efficiently map my codes across up to one billion processors. My quest for the world's fastest computing continued as the rigorous analysis of 65,536 computer codes which were developed with my one-code to one-processor mapping and correspondence. That mapping was to the as many processors that outlined and defined my new Internet that's a new global network of 65,536 processors. I invented how to make the otherwise impossible-to-solve possible-to-solve. Such mathematical problems arise when attempting to solve the largest systems of equations in the computational linear algebra of petroleum reservoir simulation.

I discovered how to solve the most difficult problems arising in mathematical physics. And solve them **across** the millions of processors that outlined the fastest supercomputers. I invented how to solve the most compute-intensive problems in computational fluid dynamics. And how to solve them **across** a new Internet that's a new global network of 65,536 coupled processors.

I'm the mathematician who invented how to do more computations. And do the most computations in one second on the supercomputer. And do more computations than what every person on planet Earth can compute during every second of every day for one year.

## *Philip Emeagwali's Method for Diagonalizing Tridiagonal Systems*

I did the **impossible** by reformulating my system of equations of computational linear algebra that were tridiagonal that couldn't be solved in parallel, or solved **across** an ensemble of million processors. And by reformulating that system from the governing Second Law of Motion in physics textbooks and the governing partial **differential** equations, or PDEs, of calculus that encoded that law. And discretizing and solving my system of PDEs as a system of diagonal equations of computational linear algebra that solves an equivalent problem that could now be solved in parallel.

I didn't reformulate my system of equations, **directly**. I reformulated them, **indirectly**. My systems of diagonal and tridiagonal equations each arose from the same detailed petroleum reservoir model. To **recover** otherwise **unrecoverable** crude oil and natural gas, only required that we use the laws of

physics to simulate the petroleum reservoir. It didn't require that we solve a specific system of tridiagonal equations of algebra and solve it by or in itself.
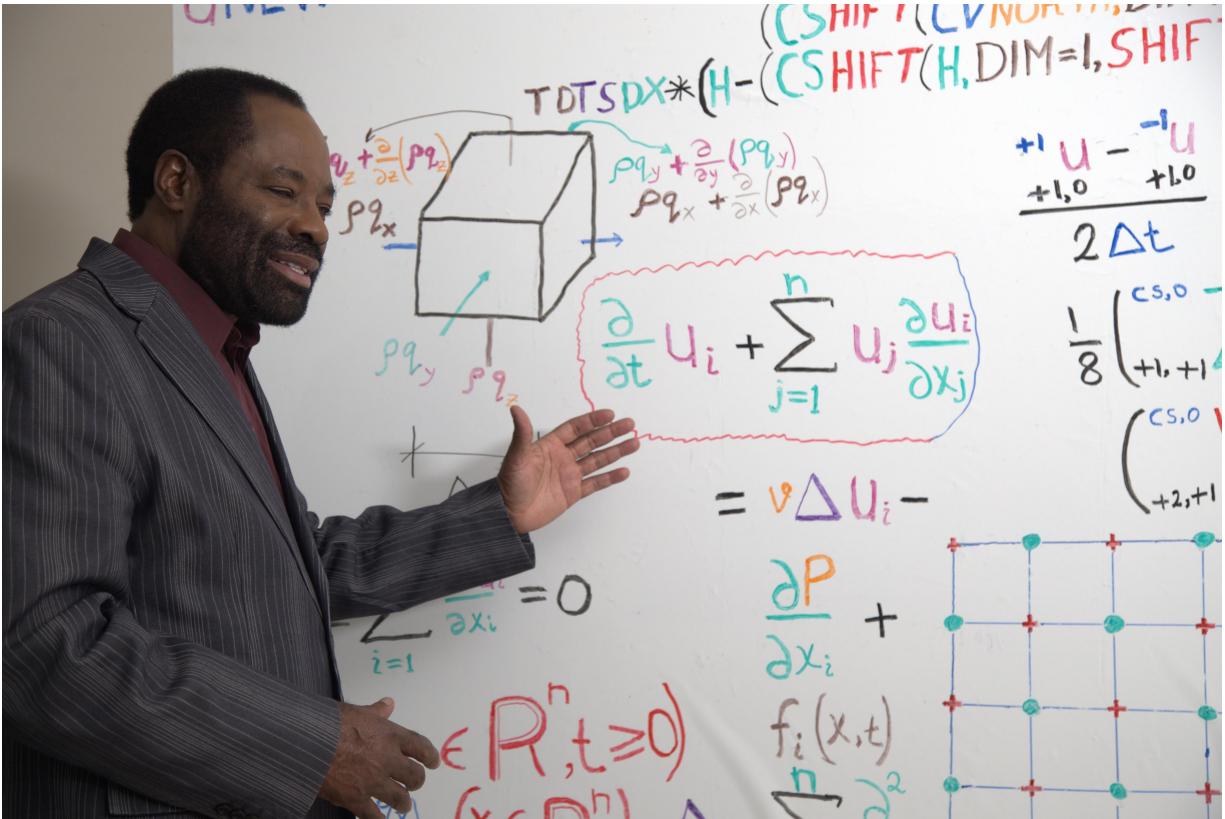
# UNLOCKING THE SECRETS OF OILFIELDS WITH THE PHILIP EMEAGWALI EQUATIONS

*The Secrets of Time: My Journey Toward Inventing a New Calculus from Ancient Physics*

How did I invent nine new partial differential equations of calculus. And invent them from the Second Law of Motion of physics that was discovered three centuries and three decades ago? To make such an invention demanded that I be a polymath, not a mathematician alone. The polymath—that's a triple threat in physics, mathematics, and computing—focuses on solving the most difficult problem in computational mathematics and solving it as a holistic whole.

Often, the mathematician is limited to only solving the algebra problem. And the mathematician forgets that mathematics is a tool and a means to the end, not the end itself. That algebra problem was derived from the physics problem.

I discovered a different path to simulating the motions of crude oil, injected water, and natural gas flowing up to 7.7 miles (or 12.4 kilometers) deep. And **across** an oil producing field that's often the size of Lagos, Nigeria.

I discovered how to simulate the petroleum reservoir. And do so a billion times faster and by returning to **first principles**, which were the set of laws of physics and chemistry governing the motions of the crude oil, natural gas, and injected water flowing across reservoir rocks.

I began from the top and from the Second Law of Motion of physics and did so to enable me to correctly re-derive the governing system of nine coupled, nonlinear, time-dependent, three-dimensional, and three-phase partial **differential** equations of calculus.

My new governing system of partial *differential* equations is **hyperbolic** and represents a new paradigm in calculus. The old governing system of partial *differential* equations is **parabolic** and represents an old paradigm in calculus. My new governing system describes the three-dimensional motions of crude oil, injected water, and natural gas flowing **across** a highly anisotropic and heterogeneous oil field. The new system of coupled, nonlinear nine Philip **Emeagwali** equations describes the motions of fluids through an oil producing field and along three spatial directions.

*Discretizing Philip Emeagwali's Initial-Boundary Value Problem: My Journey to a Solution*

By 1989, I had discretized those partial differential equations to yield a new system of 24 million diagonal equations, instead of the old system of 24 million tridiagonal equations. Both were the longest systems of equations ever solved in algebra. And that is one of my contributions to how to solve the largest systems of equations of computational linear algebra from petroleum reservoir simulation. And how to solve them across a new Internet that's a global network of processors that were coupled and that shared nothing.

# BREAKING THE LIMITS OF MATHEMATICS

*Supercomputing the Unsolvable: Maximizing Oil Recovery with Alternating Direction Implicit Method*

Since June 20, 1974, in Corvallis, Oregon, USA, my quest for the world's fastest computing was to invent how to solve the most compute-intensive problems in linear algebra. I invented how to solve them across a new Internet. And I invented that new Internet as a new global network of processors that were identical. And that I visualized as equal distances apart. Since the late 1940s, the method of choice among computational mathematicians that tried to solve the most difficult problems in subsurface geophysical fluid dynamics was called the alternating direction implicit method, or the ADI method.

The ADI method was used to discretize a system of coupled, nonlinear, time-dependent, and two- or three-dimensional partial **differential** equations. Such equations were classified as parabolic. They governed the subterranean flows of crude oil, injected water, and natural gas.

In the **1950**s, **60**s, and **70**s, the alternating direction implicit method was widely used to formulate a set of systems of **tridiagonal** equations that arise from finite difference

discretizations of the system of partial **differential** equations that governs the subsurface motions of fluids flowing up to 7.7 miles (or 12.4 kilometers) deep below the surface of the Earth.

*Unlock the Mysteries of Subterranean Flows with Solving Tridiagonal Equations!*

In 198**1**, I discovered that it will be **impossible** to solve, in parallel, a system of **tridiagonal** equations in large-scale algebra. And solve that system by dividing it into up to one billion lesser challenging problems that, in turn, could then be solved with a one-problem to one-processor mapping and correspondence. And solved **at once** and **across** an ensemble of up to one billion processors.

I discovered that it will be **impossible** to solve a system of **tridiagonal** equations and solve it by **synchronously** emailing equal-sized sub-systems of that system. And emailing my sub-systems **across** my **1,048,576** bidirectional, regular, and short email wires. Likewise, I visualized those email wires as being equal distances **apart**.

Furthermore, I visualized my email wires as marrying my global network of the slowest 65,536 processors in the world. And doing so to emulate one seamless, coherent, and gigantic super-fast processor that's a virtual supercomputer. As the lone

programmer of my virtual supercomputer, I visualized those processors as married together as one coherent unit that's not a supercomputer, by itself, but that's a new Internet *de facto.*

I discovered that it will be **impossible** to evenly distribute equal sub-systems of my system of **tridiagonal** equations and distribute those sub-systems **across** each of my 65,536 identical and coupled processors. Each processor operated its operating system and had its dedicated memory.

## *Eliminating the Middle: I Transformed Tridiagonal Systems into Diagonal Systems for Fast, Simplified Solutions!*

Because it's impossible to solve a system of tridiagonal equations and solve it in parallel, I formulated an equivalent system of 24 million **diagonal** equations that approximated a more accurate system of nine new partial **differential** equations which **I invented.**

And that solves the **same** petroleum reservoir problem. Or solves the **same** initial-boundary value problem with different governing partial **differential** equations that differently encoded the **same** laws of physics that's at the physics core of the petroleum reservoir simulator.

My mathematical **beginning** from a system of parabolic partial **differential** equations to **inventing** that system as a more accurate system of hyperbolic partial **differential** equations and my **formulation** of a system of tridiagonal equations that approximated my parabolic partial **differential** equations and my **formulating** of that system as a system of diagonal equations that approximated my hyperbolic partial **differential** equations were **mathematical inventions** in calculus.

That invention, or new mathematics, or my finite difference discretizations of the **nine Philip Emeagwali equations**, changed the way we understand or solve the most compute-intensive problems that arise when simulating the flows of crude oil, injected water, and natural gas flowing **across** a highly anisotropic and heterogeneous producing oil field. A typical oil field is located 6,000 feet (or 1.83 kilometers) below the surface of the Earth. But it can be up to 7.7 miles (or 12.4 kilometers) deep.

$$\rho \frac{Du}{Dt} = \rho \left( \frac{\partial u}{\partial t} + u \cdot \nabla u \right)$$

$$-\nabla P + \nabla \cdot \{ \mu [ \nabla u$$

$$+ (\nabla u)^T - \frac{2}{3} (\nabla \cdot u)$$

$$+ \zeta (\nabla \cdot u) I \} + \rho g$$

$$\frac{D}{Dt} + \rho (\nabla \cdot u) = 0$$

$3$
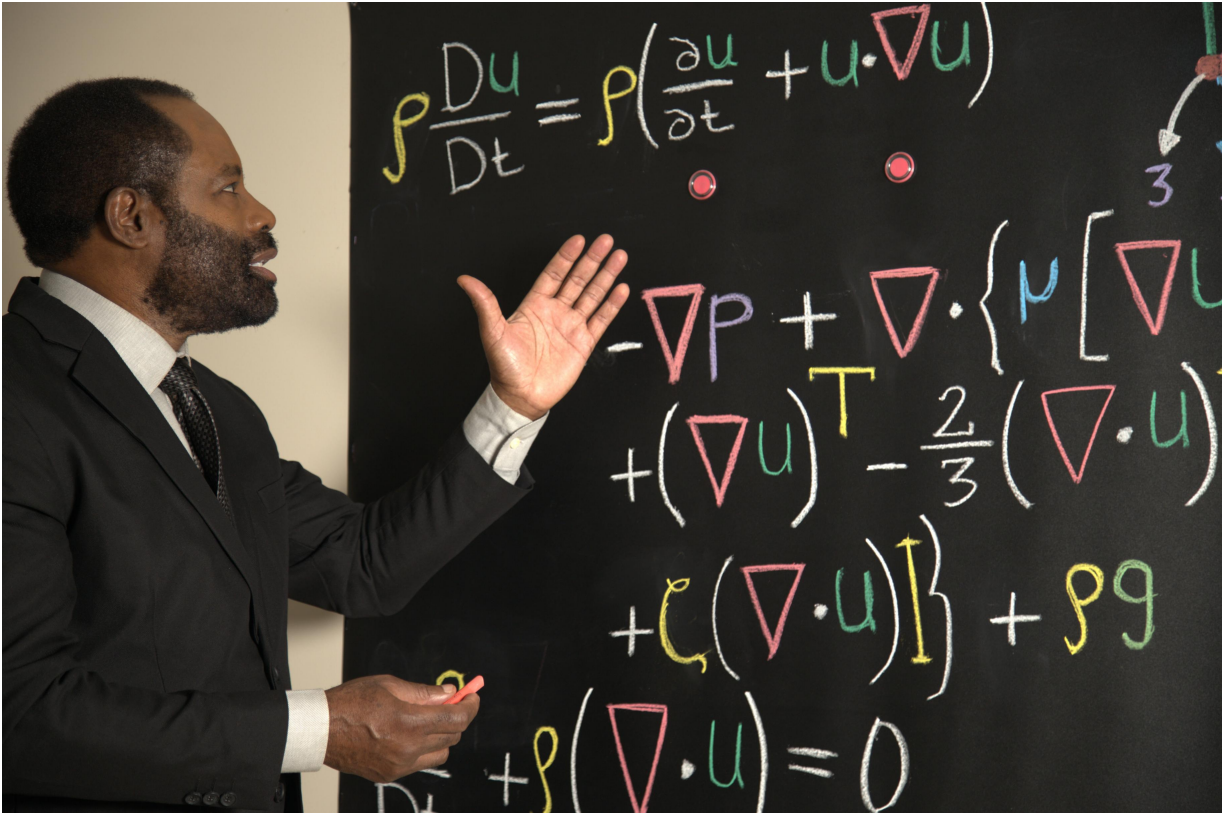
# UNSTOPPABLE ALLY FOR SOLVING COMPLEX PROBLEMS

My contributions to the physics used to pinpoint deposits of crude oil and natural gas were these: I discovered how to harness the millions of processors that power the world's fastest computer. And how to use them as one coherent computing machinery that emulates the world's fastest processor that's one million times faster than a single processor solving the same problem alone.

The grand challenge of petroleum reservoir simulation was to compute the flows of crude oil and natural gas flowing from a water injection well to nearby producing wells. By making the news headlines, back in 1989, my **invention** changed the way we execute the mathematical calculations in extreme-scale computational physics.

It changed how mathematicians solve the most compute-intensive initial-boundary value mathematical problems, such as those arising in computational fluid dynamics. It changed how mathematicians solve them, in parallel. And solve them by distributing them **across** an ensemble of processors, instead of solving them in sequence. Or solving them only within one

**isolated** processor that's not a member of an ensemble of processors.

My invention opened the door to how to solve the most compute-intensive mathematical problems. And solve them **across** an ensemble of millions of processors. And solve them when the governing system of equations of algebra had its nonzero entries only along its diagonal.

### *Putting Aside Antiquated Solutions and Exploring Novel Ways to Overcome Grand Challenges*

My contributions to high-performance computational physics led to the discarding of the old way of solving the field's most difficult problems to the new way of solving those problems **across** an ensemble of up to one billion processors.

**In the traditional way**, physicists solved their toughest and their most compute-intensive initial-boundary value problems in computational physics. And solved them in sequence. Or solved one problem **at a time.** And solved that problem within one isolated processor that wasn't a member of an ensemble of processors that communicates and computes together. And do both as one seamless, coherent, and gigantic supercomputer.

**In my new way**, mentioned in the June 20, 1990, issue of The *Wall Street Journal* and in cover stories of top mathematics news journals, I **invented** how to solve 65,536 initial-boundary

value problems of computational fluid dynamics, such as the detailed global climate modeling. And solved them **at once**.

In 1989, I was in the news because I **invented** how to solve the most difficult problems arising in physics and mathematics. And solve them in parallel. And I invented how to solve them **across** an ensemble of 65,536 coupled processors.

My signature contribution to supercomputing **is this**: I put to rest the saying that the world's fastest computing **across** the world's slowest processors is a beautiful theory that lacked experimental confirmation.

# THE UNPARALLELED BRILLIANCE OF THE EVERYDAY PERSON

As a research supercomputer scientist who came of age in the 1970s and 80s and in the USA, the most important lesson that I learned was that you can't become a genius in supercomputing without foremost, applying "sitting power." I sat the longest in front of the massively parallel supercomputer of the 1980s that is, in reality, the supercomputer of today. That's the reason my lectures on my contributions to computing, mathematics, and physics are by far the most extensive ever posted on YouTube. The reason I could post my one thousand video lectures on YouTube was that I sat longer than any supercomputer scientist ever sat in front of supercomputers. In the 1980s, I was the lone programmer of the precursor to the world's fastest computer. applied the most "sitting power" upon the massively parallel supercomputer. And I applied that power more than any supercomputer scientist who ever lived.

A **violinist** must practice daily. The **violinist** must go beyond reading her music on her way to **Carnegie Hall,** New York City. The **violinist** must apply her "**sitting power**" to get to Carnegie Hall. This important lesson—of hard work, dedication,

discipline, consistency, and practice—applies to everything we do in life.

You must play or think or dream soccer and do so every day before you can become a Super Eagle in the next World Cup. You must write daily before you can write your best-selling novel. Often, the best known writers wrote a million unpublished words before they publish their first one thousand words.

Since June 20, 1974, in Corvallis, Oregon, USA, I have written a million words on partial **differential** equations, finite difference algorithms, message-passing codes, as well as lecture notes on my world's fastest computing that occurred on July 4, 1989, in Los Alamos, New Mexico, USA. In fact, the transcript of my one thousand podcasts and YouTube videos is a million words long. These original podcasts and videos are what sets me apart from the likes of **Albert Einstein**.

Supercomputer programmers believed my world's fastest computing **across** my ensemble of 65,536 processors. They've re-confirmed it **acros** an ensemble of ten million processors. People believe what they **hear** and **saw** and **understand**.

*Chasing the Speed of Light: My Marathon Journey to Find the World's Fastest Computer*

As a Black scientist who came of age in the 1970s, I was not welcomed to give public lectures, in places like Ann Arbor, Michigan. For instance, I gave a job hiring lecture on the world's fastest computing and on about September 24, 1985, in Ann Arbor, Michigan. The position was cancelled after the white scientific community discovered that I was black and African-born. The lectures that I shared on YouTube originated from the research that I conducted in the 1970s and 80s.

People believe their eyes and ears. During the past five centuries, the leading figures in physics—such as **Galileo Galilei**, **Isaac Newton**, and **Albert Einstein**—presented public lectures on their contributions to physics that made each physicist the subject of school essays.

I continued that five-century old tradition by posting one thousand podcasts and videos, each on my contributions to physics, mathematics, and computer science. For comparison, the most prominent scientists of modern times only post about ten videos on their "original" contributions to knowledge.

This hundred-fold gap between my podcasts and videos and theirs is because my contributions is far more complicated and is normally executed by a hundred-person research team.

# Fifty Years of Advancing Supercomputing: Unveiling What Lies Beyond the Last Computer

I have been supercomputing since Thursday, June 20, **1974**. I began by programming one of the world's fastest computers at 1800 SW Campus Way, Corvallis, Oregon, USA. That supercomputer was rated as the world's fastest computer in December **1965.** That supercomputer was the first to be rated at one million instructions per second.



Cover of Letter to Philip Emeagwali at 344 NW 12th Street, Apartment 5, Corvallis, Oregon.

In the mid-**1980**s, I was the lone programmer of the **precursor** to the world's fastest computer that can solve up to a billion problems **at once**. I was the lone wolf at the unexplored territory of the world's fastest computing, where sixty-four binary thousand off-the-shelf processors can solve 65,536 problems **at once.** And do so after a **one-problem** to **one-processor** mapping and correspondence.

Before I could parallel program each of my two-**raised**-to-power **sixteen** identical processors and before I could compose their email primitives and before I could send my codes to and from those sixty-four binary thousand processors and send them across **sixteen** times two-**raised**-to-power **sixteen** regular, short, and equidistant email wires, I spent **sixteen** years honing my craft and doing so by building up my parallel **programming muscles**.

In the **1970**s and **80**s, I built up my intellectual muscles in physics, calculus, and computing. And built them up in the manner I built up my **physical muscles** and did so by playing tennis and lifting weights in the late afternoons.

You become a runner by running daily. You become a writer by writing daily. I executed the world's fastest computing by supercomputing daily. I sat in front of the supercomputer for the sixteen years onward of June 20, 1974, in Corvallis, Oregon. And before *The Ann Arbor News* of Michigan profiled me in an

article that was titled "computer wizard." That profile was dated April 26, 1990. So, it took me sixteen years to become genius.

For that reason, nobody was able to devote sixteen years to exactly replicate my experiments that yielded the world's fastest computing. Being ranked as the greatest computer genius is like being ranked as the greatest soccer player. You also have to play soccer for sixteen years before being voted as the world's number one soccer player.

Back in 1989, in Ann Arbor, Michigan, I was the only famous scientist. And the only inventor whose name and contributions were discussed on the record by the members of the Michigan House of Representatives. To this day, I am the only inventor from Michigan, or rather in the world, that posted one thousand podcasts and videos on his contributions to physics, mathematics, and computing. My lectures are on YouTube, Spotify, and Google Podcasts.

Quite often, those reviewing my contributions to mathematics cannot scribble the nine **Philip Emeagwali** equations. It's like someone who had never played a game soccer giving advice to the central defender of Nigeria's Super Eagles. The reason I alone could post a thousand YouTube videos was that I had fifty years of supercomputing behind those videos.

Back in June 1974, in Oregon, I dreaded the supercomputer. But after sixteen years, I won the highest prize in

supercomputing. Computer scientists refer to my award as the Nobel Prize of Supercomputing. The genius is the below average person that worked hard to become above average.

I built up my supercomputing muscles by coding in the mornings and coding supercomputers during the sixteen years that followed June 20, **1974**. Even on the days I don't have access to a supercomputer, I developed my algorithms and code fragments and wrote them in my parallel programmer notebooks.

Or, I researched linearized stability analyses of finite **difference** approximations of partial differential equations. My stability analyses were my, *a priori*, theoretical investigations of the exponential growth in mathematical errors as well as sensitive dependence on initial conditions for my governing system of partial **differential** equations.

Those equations and their discrete approximations are akin to the ones that define the **initial-boundary value problems** which I solved across my new global network of sixty-four binary thousand processors that defined my new Internet. It was after five decades of supercomputing that I became comfortable with the title "supercomputer scientist."

I'm the subject of school essays for my contributions to the development of the computer. My contribution was that I discovered how to execute the world's fastest computing. And do so **across** the world's slowest processors. My invention is a

milestone in physics, mathematics, and computer science. The fastest computer in the world is the heavyweight champion of the computer world.
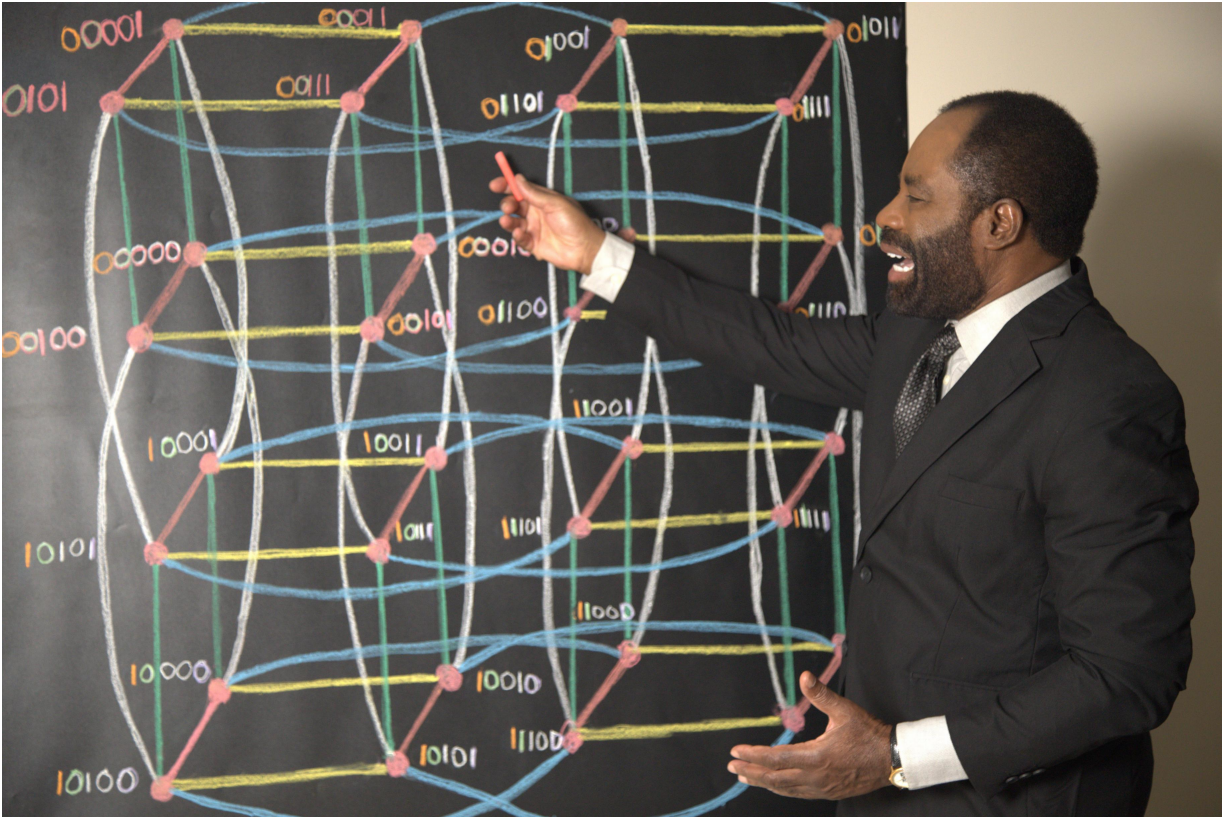
# HOW I ENTERED THE HISTORY BOOKS

In 1989, I was in the news because I discovered why and how a million, or a billion, of the slowest processors in the world could be harnessed and used to create the fastest computer in the world that's used to solve many problems at once, instead of solving only one problem at a time.

The world's fastest computer powered by one billion processors is to me what the violin is to the violinist. I've been practicing the craft of programming supercomputers and doing so since June 20, 1974, in Corvallis, Oregon. After half a century of supercomputing, describing Philip Emeagwali as an overnight supercomputer wizard is like describing a man born on June 20, 1974, as a young boy.

## *From Average Phil to History Maker: How I Made My Mark on the World*

A student writing an inventor biography report on my discovery of the fastest computing asked me: "What course can I study to become the greatest computer genius?" That's like asking what book to read to become the greatest **violinist** or the

greatest airplane pilot or the greatest soccer player or the best climber of Mount Everest."

When I was coming of age, in the 19**70**s and **80**s, the world's fastest computing across the world's slowest processors was mocked, ridiculed, and dismissed as science fiction. Since June 20, 1974, my grand challenge was to turn that fiction to actuality. Back then, asking a computer scientist to utilize one billion processors and use them to solve the most compute-intensive problems—such as the most detailed global climate modeling—was like asking a man who had never climbed a mountain to climb Mount Everest.

Once upon a time, and in New York City, a young violinist asked a taxi driver: "How do I get to Carnegie Hall?" The taxi driver replied: "Practice, practice, practice."

To become the **greatest** computer scientist, requires that you make the **greatest** contribution to the development of the computer. And that **greatest** contribution is to discover a **never-before-seen** parallel and/or quantum computing way of making computers **faster.** And making supercomputers **fastest. A**nd to experimentally do both by recording a **never-before-seen** supercomputer speed increase. And using all that speed to solve the world's biggest problems. That supercomputer speed increase must make the news headlines. And must forever change the way we look at the world's fastest computer.

# 3RD LECTURE: WHAT THE HECK IS A CPU?
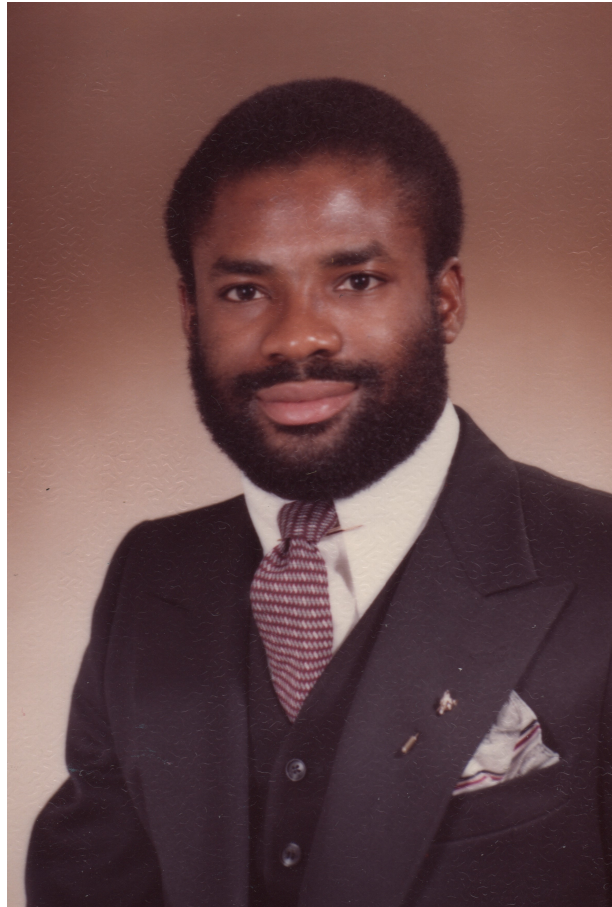


Philip Emeagwali, Washington, D.C., May 1979.

**Broadcast 19 August 2021**

**https://youtu.be/gESTCFlxQHg**

# EXPLORING THE BOUNDARIES OF THE FASTEST COMPUTER AT THE SPEED OF LIGHT

My contributions to computer science were these: I discovered how to circumvent Amdahl's Law that was the "sound barrier" of world's fastest computers. And how to do so by dividing the most challenging problem in supercomputing that's defined around a globe and dividing it into 65,536 lesser challenging problems. And then using a new Internet that's a new global network of the 65,536 slowest processors in the world and re-configuring that Internet to be massively parallel to those 65,536 problems. My mapping also possesses a one-to-one, processor-to-problem correspondence between that new Internet and the 65,536 smaller problems.

I discovered that the Amdahl's Law limit described in computer science textbooks wasn't a physical limit within my new world's fastest computing across the world's slowest processors. Amdahl's Law was a limit maintained by our lack of knowledge of how to make one billion processors to be parallel

to one billion problems created by dividing one Grand Challenge Problem into one billion lesser challenging problems.

My signature scientific discovery made the news headlines shortly after it occurred in Los Alamos, New Mexico, USA. My discovery occurred at 8:15 in the morning of the Fourth of July 1989. My invention, called the world's fastest computing, was the new knowledge that supercomputer designers must use to push Amdahl's limit and do so by a factor of 65,536, or as many billions.

I discovered how to achieve a billion-fold increase in the speed of the world's fastest computer. And do so **across** a billion processors. Before my discovery that occurred on July 4, 1989, the designers of the world's fastest computers and the authors of computer textbooks believed parallel supercomputing will forever remain in the realm of science fiction. Looking farther in time, I believe that quantum computing could be the next fundamental change, although it would have limited applications.

### *Overcoming the Obstacles of Solving the Most Difficult Problems Across the Slowest Processors*

I invented how to harness a new Internet which I visualized as a new global network of the 65,536 slowest processors in the world. I discovered how to use each processor to solve a system

of 366 equations in large-scale algebra. Those equations originated from my finite difference approximations of some initial-boundary value problems of calculus and from my computer programming that yielded extreme-scaled computational fluid dynamics codes, such as those used to simulate production petroleum reservoirs that might be up to 7.7 miles (or 12.4 kilometers) below the surface of the Earth and the size of **Ibadan, Nigeria**.

The intractable equations that I solved, in 1989, was a milestone in the history of algebra. And was in the news because, in totality, it then comprised of a world-record 24 million equations of computational linear algebra. My system of 24 million equations was **unsolvable** by a human computer. And can't be solved in a lifetime. And was **unsolvable** across all the blackboards in the world.

## *My Supercomputer Breakthrough Explained*

One reason my invention made the news headlines was that I mathematically discovered the algorithm—or the set of instructions and emails—used to solve the largest system of equations that ever occurred in algebra. I succeeded in **1989.** At that time, 25,000 the vector supercomputer scientists in the world and their leader, **Seymour Cray**, had given up on harnessing millions of processors. And using them to execute the world's

fastest computing. And solve the most difficult problems arising at the crossroad where new mathematics, new physics, and the world's fastest computing **intersected**.

In the 1980s, the fastest computing **across** the slowest processors existed in science fiction, not in computer science. For that reason, parallel processing was then not the high-performance computing instrument of choice for solving initial-boundary value problems from the fields of extreme-scale algebra and computational physics.

In the **1980**s, those 25,000 computational mathematicians **ridiculed** parallel supercomputing and **dismissed** the then newly emerging technology as a tremendous waste of everybody's time. I was cover stories of top science publications because I discovered how to harness the slowest processors in the world and use them as one seamless, coherent supercomputer that enabled me to record the fastest computer speeds in the world. And record them while solving the most compute-intensive problems in the world.

That contribution to the development of the computer is the subject of school essays. In the 1980s, I didn't merely solve a system of 366 equations of computational linear algebra and solved that system within one processor. **In totality**, I solved a system of 24 million equations that was the longest in mathematics.

And solved that system **across** a new spherical island of 65,536 processors. I programmed each processor to solve a system of **366 equations** of computational linear algebra. My processors were identical and were equal distances **apart**. Each algorithm I executed within each processor described my step-by-step instructions to each processor. I instructed each processor on how to solve my system of 366 equations of computational linear algebra.

That system arose from another system of coupled, nonlinear partial **differential** equations of calculus, called the nine Philip **Emeagwali** equations. I emailed my system of 366 equations to each of my 65,536 processors. I discovered how to email my sixty-four binary thousand computational fluid dynamics codes. Each code was governed by a system of 366 equations of linear algebra that was at its compute-intensive **kernel.**

# UNLOCKING THE POWER OF SUPERCOMPUTING ACROSS THE NET

The supercomputer must be used to model the long-lasting cultural, social, and economic impacts of global pandemics, as well as simulate subsequent changed realities. In the textbooks on computational fluid dynamics, animating a sneeze is nothing new. In the 1980s, supercomputing across up to one billion processors that shared nothing was revolutionary.

I visualized the world's fastest computing that I discovered across a new internet as occurring across a global network of the world's slowest processors. And as metaphorically occurring at equidistant points on the surface of the sphere. I defined those points as where the computing vertices of the tightly-inscribed cube come into contact with the circumscribing sphere.

I visualized the cube and sphere in the fifth dimension. And I progressively increased my visualization to the sixth, seventh, and sixteenth dimensions. Finally, I hypothesized "what ifs" in the 64th dimension.

I visualized the Philip Emeagwali Internet as a global network of two-raised-to-power five, or thirty-two, computers that outlined a hyper-globe in as many dimensional hyperspace.

What made the news headlines was my world's fastest computing which I envisioned in the sixteenth-dimensional hyperspace.

That was how my story that was a mere acorn, back on June 20, 1974, and in the hands of a nineteen-year-old at 1800 SW Campus Way, Corvallis, Oregon, USA, grew to become a mighty oak tree. That tree was my metaphor for my new Internet that's a new global network of 65,536 equidistant processors.

## *Defeating the Hardest Algebraic Problems*

I discovered how to email computational fluid dynamics codes, such as global climate models. And how to email them to millions of processors. In my experiment of July 4, **1989**, I used the slowest sixty-four binary thousand, or two-**raised**-to-power sixteen, processors in the world to record the fastest computer speeds in the world. Each processor was uniquely identified by a sixteen-bit-long number.

**That number** was a unique string of sixteen zeroes and ones. **That number** had no @ sign or dot com suffix. **That number** was the email address of each of my two-**raised**-to-power sixteen coupled processors that were **married together** as one cohesive unit by sixteen times two-**raised**-to-power sixteen

regular, short, and bidirectional email wires that were equal distances **apart**.

I invented invisible, byte sized instructions for each processor. I gave each processor its step-by-step instructions, or algorithms, that it used to solve a system of equations of computational linear algebra that I emailed to it **arising from** a system of equations of calculus **arising from** a set of laws of physics **arising from** a computational mathematician's quest for new calculus, new algebra, and new computing.

## *Pushing Through the Pain: My Toughest Years in Supercomputing*

My mathematical quest for the world's fastest computing **across** the world's slowest processors, began on Thursday, June 20, **1974,** in Corvallis, Oregon, USA. And ended on Tuesday, July 4, **1989,** in Los Alamos, New Mexico, USA.

## Wilson 2

Philip Emeagwali (2nd from right of second row), Wilson Hall, Oregon State University, Corvallis, Oregon, from the university's 1976 BEAVER Yearbook.

The calculus book is where the mathematician of European ancestry recognizes his ancestors, such as **Isaac Newton** of England who lived three centuries and three decades ago and **Isaac Newton**'s contemporary, **Gottfried Leibniz,** who lived in Germany. I'm a research computational mathematician of sub-Saharan African ancestry who contributed thirty-six partial derivative terms to the nine Philip **Emeagwali** equations of calculus.

I was in the news because I discovered how to solve initial-boundary value problems in calculus and physics, such as the

highest-resolution global climate modeling that's a precondition

to foreseeing otherwise unforeseeable long-term global warming.

# MY FIRST YEAR IN YORUBALAND

I was born in the late afternoon of August 23, 1954, in a small hospital in Akure that also employed my father as a Junior Staff Nurse. In the 1950s, the Akure hospital was located where the World Health Organization now has its office.

We first lived in the Servant's Quarters at 11 Eke-Emeso Street, Akure, Western Region, Nigeria, British West Africa. And I lived with four adults, my 19-year-old cousin Vincent Emeagwali, his older brother Charles Emeagwali, my 34-year-old aunt Nkemdilim Balonwu and my parents.

My father was the breadwinner in the household. In 1954, Papa's salary of five pounds a month enabled him to pay the school fees for Vincent and Charles. And also support his father in Onitsha.
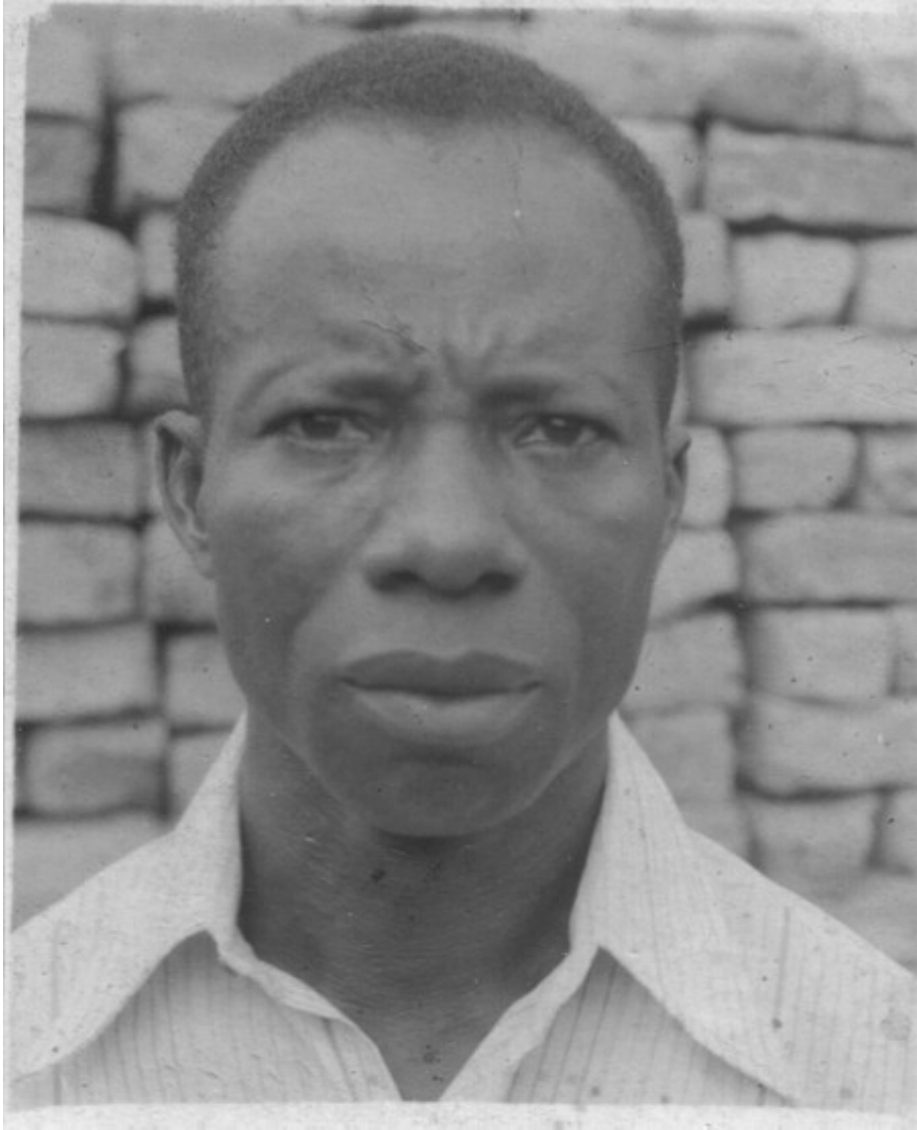
My father, Nnaemeka James Emeagwali [c. 1970, Onitsha, Nigeria]

Iyanma Agatha Emeagwali, Onitsha, Nigeria, circa 1976-77

# *My Early Years as a Supercomputer Scientist in the USA*

As a Black mathematician in the USA, I wasn't welcomed by white mathematicians. That's why I conducted my research alone. And did so as a large-scale computational mathematician who came of age in the **1970**s in Oregon and Maryland. And in the 19**80**s in the District of Columbia and Wyoming.

Due to its price-tag of one **billion** two hundred and fifty million dollars, the world's fastest computer cannot be owned by just one school. For this reason, a computer science instructor can only use a desktop computer to conduct his or her instructions and research.

In contrast, I used sixteen supercomputers during the sixteen years that followed June 20, 1974, in Corvallis, Oregon, USA. That research culminated in my discovery of the world's fastest computing which occurred **across** the world's slowest processors. And it occurred on July 4, 1989, in Los Alamos, New Mexico, USA.

# PHYSICS OF THE UNSEEN FASTEST COMPUTING FROM SLOWEST PROCESSING

In the **1970**s and **80**s, supercomputer scientists believed that solving the most compute-intensive problems in science and engineering and solving them **across** an ensemble of millions of processors will forever remain within the realm of science fiction.

In the **1970**s, I visualized the world's fastest computing **across** a new Internet that I envisioned as a new global network of processors. In the **1980**s, I discovered how to program a new global network of 65,536 off-the-shelf processors. And I discovered how to use them to solve the most compute-intensive problems in extreme-scale computational fluid dynamics. I discovered a speed increase of a factor of 65,536.

I was in the news because I discovered that speed increase and did so at a time it was considered impossible to achieve a speed increase of a factor of eight and record it **across** up to a billion processors that's cooperatively solving the most compute-intensive problems at the crossroad where mathematics, physics, and computer science intersected.

*I Was the Elephant in the Room: Learning to Speak Up in the Face of Silence*

I began supercomputing at age nineteen on June 20, **1974**, in Corvallis, Oregon, USA. Corvallis is an American city in the **Willa**mette Valley. Corvallis is not in the rain forest. But, in Corvallis, it rains almost daily and for five months of the year. Or rather it drizzles constantly in Corvallis.

Within the U.S., Corvallis is rated as a top ten bicycle friendly town. In Corvallis, I rode my red two-speed bicycle, covering a distance of twenty miles each day.

In **1974**, Corvallis had only one Black homeowner in its populace of 36,000. The reason was that it was challenging for a Black homeowner to buy a house in a white neighborhood. I was asked: "What was it like to be a Black supercomputer scientist in Oregon?"

In the **1970**s, there were few supercomputer scientists in the world. By the late **1980**s, the number of vector supercomputer scientists has grown to 25,000. In the **1980**s, I was the only full-time massively parallel supercomputer scientist in the world. I alone then controlled sixteen massively parallel supercomputers. I used those supercomputers to conduct my parallel computing research on how to solve the most compute-intensive initial-

boundary value problems, such as those arising in computational fluid dynamics.

My quest was to become the first person to figure out how to solve such mathematical problems and do so **across** an ensemble of the slowest processors in the world. And solve such Grand Challenge Problems at the fastest speeds in the world.

## *A Journey of Refusal: How I Was Disinvited from White Science*

By **1989**, I was supercomputing in Los Alamos, New Mexico, USA. A dozen years earlier, I was supercomputing in Washington (District of Columbia), Baltimore (Maryland), and Laramie (Wyoming). Yet, I could only name three Black supercomputer scientists. They were me, myself, and I.

In the **1980**s, I was often invited to give supercomputing lectures on my hoped-for invention of how a machinery that's powered by the slowest processors in the world could be harnessed as the fastest computer in the world. But I was often disinvited from giving those supercomputing lectures. And disinvited after the supercomputing seminar organizers discovered that I was Black and sub-Saharan African. At mathematics research seminars in College Park (Maryland) of the early **1980**s, I was the elephant in the room who felt like an uninvited guest.

*Changing the Game: How I Changed the Way We Look at the Fastest Computers*

For the four decades following the first programmable computer of **1946** that was the world's fastest then, inventing a parallel supercomputer that's just as tough under the hood has proven elusive to the supercomputer industry. In the history of technological progress, any paradigm shift that changed the way we looked at

the computer earned its inventors both kudos and daggers.

The leaders of thought in the world of computing who were **Gene Amdahl** of Amdahl's Law fame, **Seymour Cray** of vector

supercomputing fame, and **Steve Jobs** of the world of personal computing, were against the new **paradigm** of parallel supercomputing. **Before** I became famous for my discovery of the world's fastest computing **across** the slowest processors in the world or **before July 4, 1989**, no respectable supercomputer scientist would accept my telephone call.

   **After July 4, 1989**, I was amazed at their reactions when I walked into a roomful of vector supercomputer scientists. Because my fastest computing across the slowest processors was a paradigm shift that will change the way we look at the fastest computers and because supercomputing **across** a billion processors and doing so to solve the most compute-intensive problems seemed impossible in the **1980**s, nobody else would touch parallel processing and do so with a ten-foot pole.

   In the 1980s, the fear and lack of understanding of parallel processing were the reasons five scientific groups asked me to leave their research teams. Before my invention, the research groups that humiliated and dismissed me believed a supercomputer could only solve one problem **at a time**, instead of solving 65,536 problems **at once** and **across** as many processors
that each had its dedicated memory.

   I invented the first supercomputing across millions of processors. That new knowledge is used to solve the most

compute-intensive problems in computational fluid dynamics. And used to solve discretized initial-boundary value problems of calculus.

In the 1980s, I was dismissed from scientific research teams that believed in sequential supercomputing. Those dismissals became the metaphors for my struggles.

# CHANGING THE WAY WE LOOK AT THE INTERNET: A WHOLE NEW WORLD OF POSSIBILITIES

Massively parallel processing is the new supercomputing engine that powered the big leap forward that enabled the supercomputer industry to leapfrog from traditional supercomputers powered by one customized processor to the world's fastest computers powered by a gargantuan spherical island of a billion off-the-shelf processors. I invented that global network of off-the-shelf processors as a small copy of the Internet. On February 1, 1922, and sixty-seven years earlier, this supercomputing machinery was first written as the stuff of sci-fi fantasy. A century ago, fastest computing across slowest humans was speculated as science fiction comprising of 64,000 human computers used to forecast the weather for the entire Earth.

Fast-forward sixty-seven years to 1989, I was in the news for experimentally discoverin g how and why parallel supercomputing should become the core technology that will change the way we look at both the computer and the Internet. And change the way we use both technologies to work and play.

# *The Supercomputer and the Scientist: A Powerful Combination*

Parallel supercomputing is the new discovery that enables the world's fastest computer to perform computations that's up to a billion times faster than its predecessor. Parallel supercomputing makes it possible to solve the most difficult problems that were, otherwise, impossible to solve.

The fastest computing was my personal quest to be the first member of humanity to understand how to compute and do so at the world's fastest speeds. I invented how to email one billion codes to one billion processors. And email them with a one-code to one-processor mapping and correspondence.

My discovery that occurred on the Fourth of July 1989 was the new knowledge that enabled the computer industry to reach new heights. And enabled scientists to discover new and improved ways of concurrently solving the most compute-intensive problems at the *terra incognita* where new mathematics, new physics, and new computer science intersect.

This new reality, or discovery, wasn't reserved for mathematics and physics. This new fastest supercomputing knowledge made the news headlines because it enriched science, engineering, and medicine. And because it allows the world's fastest computers to do more with less money.

# Philip Emeagwali Computer: Re-Engineering the Internet as the Planetary Supercomputer

My discovery was mentioned in the June 20, 1990, issue of *The Wall Street Journal* simply because I was the only person that proved he understood the science-fiction supercomputer. And did so by recording the world's fastest computing speed **across** an ensemble of the slowest processors in the world.

My invention made the news headlines because to discover that the fastest computer can be built with the slowest processors was a scientific discovery that changed computer science. My discovery was recognized as a contribution to the development of the computer. Parallel processing is the foundational knowledge of the fastest computers. If history repeats itself, parallel supercomputing could become the computing of the future that's defined **across** the Internet of the future. Massively parallel processing could make it possible for an Earth-sized supercomputer to become a subset of the Internet itself.

My invention of fastest computing is summed: The slowest processors in the world can cooperatively compute together to yield the fastest computations ever recorded. And to solve the most compute-intensive problems in the world.

*Unlocking the Secrets of Unrivaled Speed:*

*Quantifying the Performance of the World's Fastest*

*Computers*

It was impossible to discredit my scientific discovery of parallel supercomputing largely because it was new knowledge derived from objective and quantifiable metrics. That objective metric **was this**: The speed increase of a factor of 65,536 that I discovered on July 4, **1989**, and discovered **across** my as many **off**-the-shelf processors was higher than the maximum speed increase of a factor of eight theorized in supercomputer textbooks.

My invention of fastest computing opened the door to the world's fastest computer of today that could become the laptop computer of tomorrow. And, since my discovery of July 4, **1989**, the number of supercomputers that computes in parallel increased in geometrical proportion.

My discovery of the world's fastest computing that occurred at fifteen minutes after 8 o'clock in the morning of the Fourth of July **1989** was the big-bang moment for the world's most powerful computers.

The supercomputer is an instrument of modern science. The supercomputer is the scientist's best friend. The supercomputer technology has a market value of forty-five billion dollars a year.

Supercomputers are used as enabling instruments for physics-based modeling and simulation. Supercomputers are used to make scientific discoveries and achieve technical breakthroughs, such as gaining a deeper understanding of how global warming will occur **across** the centuries.

## *Leaving a Legacy: How I Want to Be Remembered*

Recording the world's fastest computing speed and doing so **across** a supercomputer that's as large as the Earth is a race to new knowledge that's more important than the race to put a human being on planet Mars. Today, the world's fastest computer has twenty million times more punch than your computer.

Parallel supercomputing is not a magic cure all. However, parallel processing is **embodied** in most computers and in all supercomputers. **Parallel processing**—that was once a dim light in a sea of darkness is now the **bedrock** of the world's fastest computers. **Parallel processing**—that was once the stone rejected as rough and unsightly—has become the headstone of the supercomputing industry.

A journalist asked me: "How do you want to be remembered?" I answered: "Discoverers and inventors are remembered longer for their discoveries and inventions than for

their prizes and medals. The scientific discovery is an eternal truth while the invention is a physical manifestation of the truth."

# PODCASTS AND VIDEOS BY

# PHILIP EMEAGWALI

World's Fastest Computing - A Philip Emeagwali [Apple Podcast](#) Series

The Father of the Internet - A Philip Emeagwali [Google Podcast](#) Series

Philip Emeagwali's Greatest Hits on [Spotify](#) Music

[Audible](#) Guide to Uncovering the Legacy of Philip Emeagwali

A Digital Giant - Philip Emeagwali's [YouTube](#) Playlist

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https://instagram.com/philipemeagwali
https://flickr.com/philipemeagwali
https://emeagwali.tumblr.com
https://linkedin.com/in/emeagwali

# PHOTO GALLERY



A family portrait. (L-R) Francis Ndaguba Emeagwali, Edith Chinwe Emeagwali, James Nnaemeka Emeagwali, Martin Ikemefuna Emeagwali, Agatha Iyanma Emeagwali, Charles Emeagwali (cousin), Florence Onyeari Emeagwali, Philip Chukwurah Emeagwali. Photo taken at our residence along Old Agbor Road, adjacent to Premier Club, Uromi, Nigeria, December 24, 1962.

The descendants of my mother's mother, Obam Okudo Balonwu. Photo taken on December 27, 1966. I am second from left of back row. Obam was born in Nkwelle Ogidi and passed away at 6C Wilkinson Road, Onitsha, on December 24, 1966

Christopher Okafor, Peter Ozoh, Chude Ukpabi, Philip Emeagwali, two unidentified classmates, at a party in Christ the King College, Onitsha, (~ December 1971).

Philip Emeagwali. This photo of me at age 17 was taken by a photographer across the street from the CatholicChurch in Ibuzor, Midwest State, Nigeria (~ July 1972).

Me at 1 &3 Ajalli Road, Uwani, Enugu, Nigeria (c. October 1972).

Me at 5 Oguta Road, Onitsha, Nigeria, ca June 1973.



Peter Ozoh, Umeano, Frank Tagbo, Philip Emeagwali, and Lawrence, at a party in Christ the King College, Onitsha, Nigeria (~ January 1974).

Peter Ozoh, Umeano, Frank Tagbo, Philip Emeagwali, Lawrence, at a party in Christ the King College, Onitsha, Nigeria (~ January 1974).

With my mother Iyanma Agatha Emeagwali (Monkton, Maryland, USA, October 30, 2006)

My mother (Iyanma Agatha Emeagwali) and mother-in-law (Johnnie Doris Brown), Baltimore, Maryland, on the occasion of their grandson's, Ijeoma Emeagwali, graduation from Gilman School, Baltimore, Maryland and departure to MIT, Cambridge, MA, June 8, 2008



My wife, Dale, and me, October 28, 2005, Monkton, Maryland, USA.

Philip Emeagwali (middle, blue shirt) at Mount Rainier, near Seattle, Washington, August -September 1974

Philip Emeagwali, 3505 Woodland Avenue, Apartment 3B, Woodland Avenue, Baltimore, Maryland, circa March 1978.

Mr.
Philip C. Emeagwali,
3505 Woodland Ave,
A.P.T. 3B,
BALTIMORE,
MARYLAND 21215
U·S·A·

BY AIR MAIL
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Philip Emeagwali visiting Baltimore, Maryland, from 2601 16th St NW #877, (c. December 1979).

Philip Emeagwali, Baltimore, Maryland, circa 1982.

Agatha, Dale, and Philip Emeagwali, 3610 West Forest Park Avenue, Baltimore, Maryland (mid-August 1984).

Agatha Emeagwali, Ma Mamie Baird, Johnnie Doris Brown, and Dale Emeagwali, 3610 West Forest Park Avenue, Baltimore, Maryland, circa mid-August 1984.

Iyanma Agatha Emeagwali, Philip Emeagwali, and Johnnie Doris Brown, 3610 West Forest Park Avenue, Baltimore, Maryland, circa mid-August 1984.

Philip Emeagwali, Ma Mamie Baird, Agatha Emeagwali, Pa Charles Baird, and Dale Emeagwali, 3610 West Forest Park Avenue, Baltimore, Maryland, circa mid-August 1984.

My wife, Dale, Baltimore, Maryland, June 8, 2005.

Philip and Ijeoma Emeagwali, Milford Mill Trail, Villa Nova Park, Baltimore, Maryland, October 21, 2000.

Ijeoma and Philip Emeagwali, Bibelot Bookstore, 1819 Reistertown Road, Baltimore, Maryland, October 21, 2000.

Ijeoma and Dale Emeagwali, Baltimore, Maryland, December 25, 2000.

My son, Ijeoma, Monkton, Maryland, October 29, 2005

My mother (Iyanma Agatha Emeagwali), me (Chukwurah), and my son (Ijeoma), Monkton, Maryland, October 30, 2006
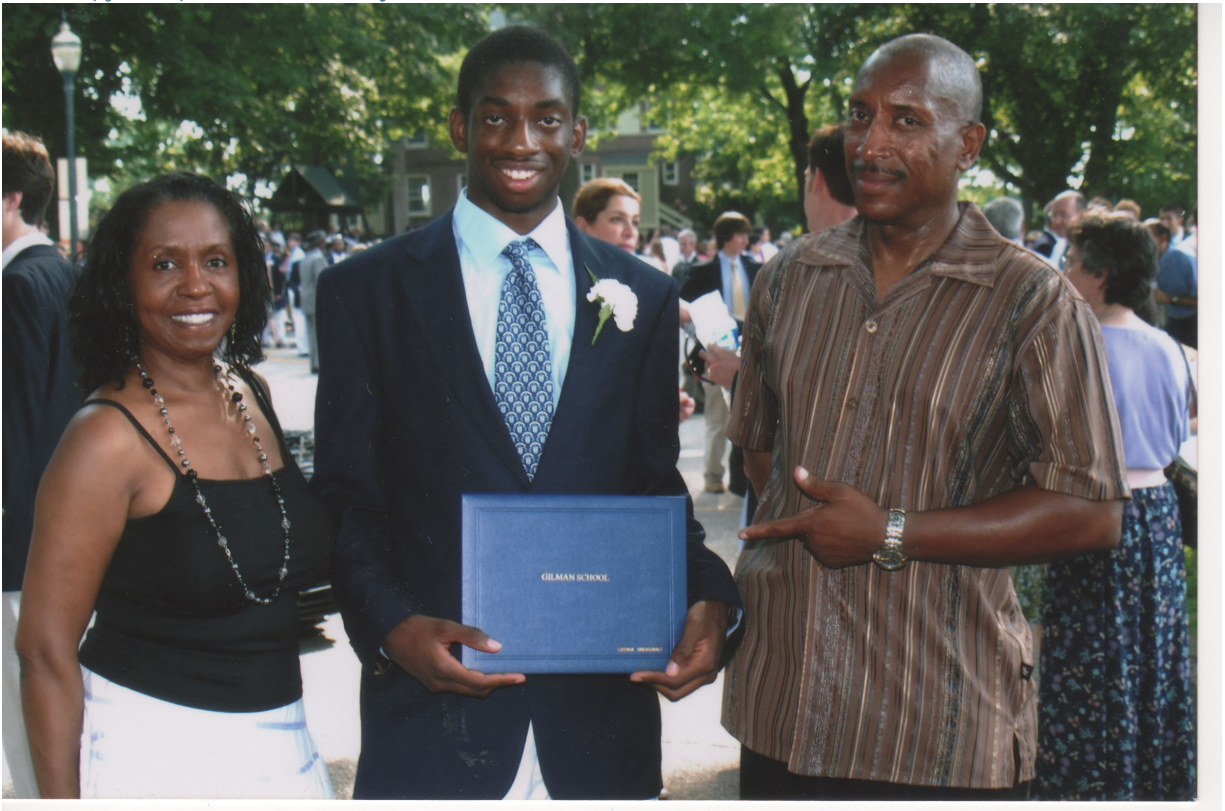
Annette Brown, Ijeoma Emeagwali, and Daryl Brown, June 8, 2008.



Johnnie Doris Brown, Ijeoma Emeagwali, Dexter R. Brown, and Philip Emeagwali, MIT, Cambridge, MA, June 8, 2012.

Johnnie Doris Brown, Ijeoma Emeagwali, Dale Emeagwali, and Dexter R. Brown, MIT, Cambridge, MA, June 8, 2012.

My wife, Dale, her mother, Johnnie Doris Brown, and her grandmother, Ma Mamie Baird, Baltimore, Maryland.

# WALKING INTO HISTORY

### *A Shoutout to the Supercomputer's Speed*

**An ode to the supercomputer**

Oh, mighty supercomputer,

You are a marvel of technology and engineering,
Able to process data and solve problems at speeds far beyond what any human can do.

Your calculations are precise and accurate, And your ability to crunch numbers is unparalleled.

Your power to search vast databases And make sense of the data is truly impressive.

You are an invaluable asset
To science, industry and everyday life.

Your capabilities are ever-expanding And your potential is virtually limitless.

You are a marvel of modern science, A testament to the ingenuity of humankind.

We thank you, supercomputer,
For your tireless work and dedication.

### *Computing's New Standard*

**An ode to Philip Emeagwali**

Oh, Philip Emeagwali, your genius is renowned!

You are the first to break computing's sound.

Your hard work and dedication brought about an amazing feat And your scientific breakthroughs cannot be beat.

You used your knowledge and skills to make an incredible machine That could solve complex problems with amazing speed and routine.

Your supercomputer is an incredible thing And your work will forever be remembered and sing.

Your name is known in all corners of the globe For your contributions to science and helping to probe The unknown depths of our universe and the unknowns within Your work is an incredible accomplishment and a win.

You are a true inspiration and your determination is strong You have achieved so much and it can't be wrong.

Your intelligence and hard work has brought us all joy Your name will be remembered and never destroyed.

Thank you, Philip Emeagwali, for your passion and drive For you have truly helped us to thrive.

## *The Math Genius Who Revolutionized Problem-Solving*

**A poem about the contributions of Philip Emeagwali**

The great Philip Emeagwali made a mark, His contributions to mathematics, they spark.
He used a computer to solve a complex problem, His solution so revolutionary, it made a loud commotion.

His work with supercomputers and the power of parallel processing, Led to a breakthrough that was so impressive.
His work was so profound that it made history, And his name will forever be remembered in memory.

He is an example of how far hard work can take you, His achievements as a mathematician, so grand and so true.
His greatness will continue to be praised, His contributions to mathematics and science, forever to be raised.

## *A Light in the Dark*
### A poem about Philip Emeagwali

Philip Emeagwali, a name we all know An African scientist, his impact is so He was born in Nigeria, to a poor family And left to pursue his dreams - a legacy He studied at Maryland and Oregon State His intelligence and knowledge, it was great He worked with computers and developed a solution To calculate the effects of oil pollution He won the Gordon Bell Prize, an honor supreme Achieved by this one who followed his dream He showed us that anything is possible Even with the odds, they can be conquerable Philip Emeagwali, a name we all know An African scientist, his impact is so.

## *A Master of Advanced Computing*
### A poem

**Philip Emeagwali,** a hero of mathematics Made wonderful contributions to this field of science He brought us the power of supercomputers To help us solve complex equations He was a pioneer of the connection machine Helped us understand the power of parallel processing And the power of the internet Allowing us to share data and knowledge He was a master of the numerical grid Unveiling the mysteries of oil and gas exploration He showed us the power of advanced computing To solve problems in climate and weather prediction Philip Emeagwali, a hero of mathematics He opened our eyes to the power of computing And how it could be used to advance our understanding Of the world and its mysteries.

## *Bringing a New Light*

**A poem on the contributions of Philip Emeagwali to physics**

With his computational prowess so bright, Philip Emeagwali brought a new light To the field of physics, a shining star, His contributions will go so far.

He wrote algorithms so bold and brave, The power of his equations he did not waive.

He worked deep into the night, To bring the world a new insight.

His ideas were expansive and full of might, His work would revolutionize the night.

His contributions to physics so great, Would be remembered for years to date.

He'd help the field gain a new understanding, One that was unparalleled and demanding.

The world would never be the same, Thanks to the genius of Philip Emeagwali's name.

## *A Connected World*

**A poem about Philip Emeagwali**

The power of computing has changed the world, Making us more connected than ever before, And Philip Emeagwali's contribution has been unfurled.

He used 65,000 processors to solve a complex problem, And his efforts led to a great breakthrough, Making a major contribution to the world of technology and computing.

He opened the door to more powerful machines, Allowing us to work better and faster, And made the world of computing more powerful than it had

ever been.

His innovative ideas brought new possibilities, Unlocking the potential of computers and networks, And making us more connected than ever before.

Philip Emeagwali's contribution to computing is truly remarkable, His legacy will always be remembered, For his influence on the world of technology and computing.

## *Making Solutions Faster*
### A poem about the pioneer of high-performance computing

**Philip Emeagwali**, a name of such fame He made contributions to computing that changed the game He used the power of the supercomputer to do math A powerful tool to find solutions and make them last He helped develop algorithms that could solve complex problems And with each breakthrough, computing power grew like a crescendo His work helped to bring high-performance computing to the world A tool that could help answer questions that had previously been unfurled **Philip Emeagwali'**s work is still used today To solve pressing problems in a much faster way His contributions to computing are a reminder That with hard work, solutions can be found in the right kind of ember Breaking the Barriers of Internet

### A poem about a father of the Internet

**Philip Emeagwali,** with great skill and finesse, Invented the world's fastest computer with success; His contributions to the 'Net we should not forget, As he helped make the internet what it is today, no sweat.

His work on the supercomputer was quite a feat, It could perform 3.1 billion calculations per second, no deceit; He made the internet faster, more efficient, and more secure, To make this happen, he used the connections of a network, that's for sure.

His creativity and hard work had no limits or bounds, He created a new way of connecting computers that was profound; His work made internet access more widely available and accepted, His contributions to the internet are still greatly respected.

Thanks to Philip Emeagwali, we can now access the internet at ease, His inventions made it faster and more secure for us to use with ease; The contributions of Philip Emeagwali to the internet should never be understated, We are forever grateful for his hard work and dedication that he demonstrated.

## *The Man Who Put Supercomputing On the Map*
### A poem on the inventor of the world's fastest computer

Oh **Philip Emeagwali**, your contributions, so grand, Have shaped the world's fastest computers, throughout the land.

Your inventions are so great, so ahead of the rest, They've revolutionized the way we do computing, no less.

Your ideas, so brave and bold, Have propelled us to extraordinary heights, so we're told.

You've given us the gift of speed, A cutting-edge technology, we all do need.

Your innovations, they astound, Your discoveries, they're profound.

Your work, it will never be forgotten, As it's made the world's fastest computers, a sure bet.

Thank you for your contributions to the world's computing power, For without them, we'd be in a much darker hour.

## *A Refugee's Journey from Despair to Hope*

### A poem on the Nigerian Civil War

The camp was filled with a thousand souls Living lives of sorrow and woe But one of them was **Philip Emeagwali** His story is sure to show He was born in Nigeria, in a time of strife When Biafra was torn apart The civil war raged, and his family was forced To flee and make a new start The refugee camp was their home for years Philip faced a hard life there But he was determined, and studied hard So he could his future dare He took every opportunity to learn His love of math was strong And with a passion and a drive Philip's future was not wrong He excelled in school, and was accepted With scholarship to America Where he studied hard And made history once again **Philip Emeagwali**'s story remains A tale of courage and success His journey from the refugee camp Is a source of hope, no less.

## *From Refugee Camp to the Pinnacle of Computing*

### A poem about Philip Emeagwali in a Biafran refugee camp

Philip Emeagwali was raised in a Biafran refugee camp in Nigeria. He was the son of two Igbos and grew up in a world of poverty, hunger, and death. Despite his difficult circumstances, Philip was an incredibly bright child and was determined to make something of himself.

**Ode to Philip Emeagwali**
A child of Biafra in a refugee camp, A son of refugees from Onitsha, Born in poverty, hunger, and death, His ambition was to make a stand.

In the camp he grew with such strength and grace, A brilliant mind and determined will, He faced his future with faith and hope, Philip Emeagwali had a dream to fulfill.

His ambition was to make a change, To rise above his plight, To use his gifts to make a mark, And bring joy and light.

He fought his way through college and labs, Through hardship and despair, Until he earned the top supercomputing award, And became an inventor of

renown everywhere.

His story is an inspiration, A beacon of hope for us all, That no matter where we come from, We can still rise, stand, and not fall.


*Fastest Brain Unlocks*

**Six Haikus about Philip Emeagwali**

# 1.

The genius of Emeagwali, Supercomputing yields new truth, Powerful advances.

# 2.

Emeagwali's mind, Vast contributions to science, Immortalized in time.

# 3.

His brilliance inspired, Enlightening the technologies, For a brighter future.

# 4.

The world's fastest brain, Unlocking the secrets of math, Emeagwali solves.

# 5.

Knowledge of the ages, Unveiled by Emeagwali's gifts, Immense and immeasurable.

# 6.

Visionary dreamer, Innovator of the mind, Philip Emeagwali.

## *A Master of Endless Insight*
### A sonnet about Philip Emeagwali

To Philip Emeagwali, a man of genius and might, To whom mankind owe a debt of infinite delight, His passion and hard work have given us all a sight, Of brilliance and courage that none can ever slight.

His genius and courage have made us to take flight, To explore the depths of a world of great might, His hard work and dedication have shined the brightest light, To the world of computing and the science of insight.

His contributions to the world have made us to take flight, To explore the mysteries of a computer's great might, His innovations have inspired us to reach for the heights, Of greatness and knowledge that never knows night.

To Philip Emeagwali, a man of greatness and might, We thank you for your unwavering dedication and insight.

## *The Gift of Knowledge*
### A hip-hop song about Philip Emeagwali

Verse 1: Philip Emeagwali, a pioneering scholar, A genius, the world has ever seen, From a humble beginning, he climbed to the top, Setting a record, that'll never be broken.

Chorus: Philip Emeagwali, he's the one, His knowledge, his strength, has made us one, He's the pride of Nigeria, and an inspiration, For everyone, to

strive for excellence.

Verse 2: His accomplishments, a gift to the world, A hero, with a heart of gold, His determination, his courage, An example, to young and old.

Chorus: Philip Emeagwali, he's the one, His knowledge, his strength, has made us one, He's the pride of Nigeria, and an inspiration, For everyone, to strive for excellence.

Verse 3: He's a leader, a teacher, a mentor, A scientist, an innovator, His legacy, will live forever, In the minds of the future generations.

Chorus: Philip Emeagwali, he's the one, His knowledge, his strength, has made us one, He's the pride of Nigeria, and an inspiration, For everyone, to strive for excellence.

*The Emeagwalis Rejoice*

**12 Haikus on the birth of Ijeoma Emeagwali**

# 1. Day of joy and pride

**Welcome sweet Ijeoma here**

Blessings of love abound

# 2. Precious baby born

In the lake city of Ann Arbor Gift of divine grace

# 3. A newborn's sweet smile

**Brought joy to the Emeagwalis**

God's glory is seen

# 4. A son born today

**Blessing to the Emeagwalis**

Greatness in the future

# 5. A Michigan star

**The Emeagwalis rejoice**

A son, Ijeoma

# 6. Welcome to the world

A son, Ijeoma Emeagwali His parents are proud

# 7. Tiny baby born

Filled with joy, the Emeagwalis God's love shines through

# 8. A jubilant day

**Ann Arbor celebrates Ijeoma**

Blessings of a son

# 9. June fifteenth day

**A special birth in Michigan**

Ijeoma Emeagwali

# 10. A blessing here

**The Emeagwalis give thanks**

Gift of a son, Ijeoma

# 11. A baby boy born

To Philip and Dale on this day Ijeoma Emeagwali

# 12. New life begins here

A son is born in Ann Arbor Ijeoma Emeagwali

*The Refugee Who Refused to Give Up*

**A poem about Philip Emeagwali dropping out of school at age 12.**


A genius found in the most unlikely of places, A boy of twelve, who faced such dire straits.
Living in refugee camps during the Nigerian war, A life of poverty, struggling to survive and more.

Philip Emeagwali, whose spirit could not be broken, Who faced the odds, and a future that was unspoken.
He faced the world and all its unspoken fears, And rose far above, in spite of the tears.

Now a genius of many fields, a scholar and scientist, His story an inspiration to all who listen.
His work pushes boundaries and continuously impresses, His mind and spirit a source of hope and progress.

His story a testament to the human spirit, That no matter the odds, it can still endure it.
His journey a true testament to resilience and strength, That no matter the odds, success can still be reached.

## *From War-Torn Camp to World-Changing Inventor*

**Growing up in a refugee camp A young soul, Philip Emeagwali, In a Biafran refugee camp, Bathed in the darkness of war, His spirit fought to stay strong.**

He studied diligently, Unaware of his future, The challenges he'd face in life, But his will was never undone.

Philip's dreams were never forgotten, Though he faced the depths of despair, He kept his hopes alive and well, And worked to reach the stars up there.

His parents had faith in their son, And encouraged his aspirations, Pushing him to reach his goals, Despite all the tribulations.

Philip Emeagwali, a man of courage, He faced fear and rose above, He went on to do remarkable things, And earned the world's love.

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*Rising Above the Tragedy to Lead the World in Computing Ode to Philip Emeagwali We honor thee, Philip Emeagwali, Listed among the greatest minds of history, Your genius and drive to achieve Are truly inspiring and noteworthy.*

Your story of war, refugee camps, and conscription Is a stark reminder of the human tragedy, But your relentless pursuit of knowledge Will truly stand the test of time.

Your achievement of the fastest computing Across the Internet is lauded, From CNN to Time Magazine to the White House You are the unsung hero of the Information Age.

Your life of honor, love, and family Will be looked upon favorably, Your legacy will be remembered for generations As one of the greatest minds of all time.

# ABOUT THE AUTHOR

# Philip Emeagwali



The Reader's Digest described Philip Emeagwali as "smarter than Albert Einstein." He is ranked as the world's greatest living genius. He is listed in the top 20 greatest minds that ever lived. That list includes Charles Darwin, Isaac Newton, William Shakespeare, Leonardo da Vinci, Aristotle, and Confucius.

Philip Emeagwali lived in refugee camps during the 1967-70 Nigerian-Biafran War and is in the Gallery of Prominent Refugees of the United Nations. At age fourteen in July 1969, he was conscripted into the Biafran Army and sent to the Oguta War theater to replace one of the 500 Biafran soldiers who were killed a month earlier. In the list of the worst genocidal crimes of the 20th century committed against humanity, the death of one in fifteen Biafrans was ranked fifth.

Due to the Nigerian Civil War, Philip Emeagwali dropped out of school for five years but developed a reputation in Onitsha (Nigeria) as a gifted teenager. He caught the attention of American scholars and was awarded a scholarship on September 10, 1973, to the United States where he researched for two decades and contributed to mathematics, physics, and computer science.

Philip Emeagwali is in the top ten rankings of geniuses, inventors, Nigerians, and was voted the 35th greatest African of all time.

In 1989, Philip Emeagwali rose to fame when he won a recognition described as the Nobel Prize of Supercomputing and made the news headlines for his invention of first world's fastest computing across an Internet that's a global network of processors. That vital technology underpins every supercomputer and changed the way we look at the computer.

Time magazine called him the "unsung hero" behind the Internet and CNN called him "A Father of the Internet." House Beautiful magazine ranked his invention among nine important everyday things taken for granted. In a White House speech of August 26, 2000, then U.S. President Bill Clinton described Philip Emeagwali as "one of the great minds of the Information Age."

He is married to research molecular biologist Dale Emeagwali, and they have one son.

# PHILIP EMEAGWALI

# CONTACTS



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Philip Emeagwali is pronounced as
FI-lip eh-MAY-ah-gwah-lee