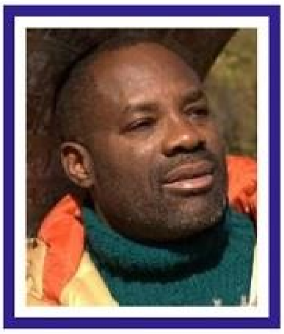
52 Father of Large-Scale Algebra—Part 4 of 10



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52.1 On Crossing New Frontiers in Algebra to Conquer Today's Challenges.

To discover and recover
otherwise elusive

and unrecoverable
crude oil and natural gas
and to do so from the Niger-Delta region
of southeastern Nigeria
demands that we **cross** new frontiers
in extreme-scaled algebra
and high-performance supercomputing.
Algebra
is the elephant in the room
that must be conquered
before we can solve today's
toughest problems
that arise in physics, mathematics,
and computing.
Algebra
is the recurring decimal
and the common denominator
at each processor
that outlined the massively
parallel processing supercomputer.
For example,

the community atmospheric model
has 530,000 lines of code
and has algebra
at its most computation-intensive core.

52.1.1 Contributions of Philip Emeagwali to Algebra

My contributions to algebra
are these:
I invented
how to solve the toughest
and the most important problems
arising in algebra,
such as the
community atmospheric model.
I invented
how to solve the most large-scale
system of equations
of algebra
and how to solve them
across a new internet

that is a new global network of
65,536 tightly-coupled processors
that shared nothing with each other
and that were already available
in the market anyway.
The computation-intensive
mathematical problems
that I emailed **across**
my new internet
consisted of a set of system of equations
of extreme-scale algebra
that arose from my discretizations
of a system of
partial differential equations
of modern calculus,
that also encoded
a set of laws of physics.
I experimentally discover
that massively parallel processing
enables the extreme-scaled
computational physicist

to solve the largest systems of equations 2544
that arise in algebra
and that is the precondition
to executing
the most excruciatingly-detailed
simulations, such as the
general circulation model
that must be used to foresee
otherwise unforeseeable
long-term climate changes.
My invention
of the massively parallel processing
supercomputer
changed the way we look at
the modern computer
and became my contribution
to the development of the computer.
I am the subject of school reports
in U.S. schools
because my contributions
to the development of the

massively parallel processing
supercomputer
has rich and fertile consequences
for society.

52.1.2 Philip Emeagwali's Quest for New Algebra

For me, **Philip Emeagwali**,
my experimental invention
of how to massively parallel process
the toughest problems
arising in algebra
was the culmination
of my silent sixteen-year-long journey
that began in the early morning of
Thursday June 20, 1974.
My quest for the fastest supercomputer
began in a small room
that was upstairs of a **white house**
at 195A Knox Street South,
Monmouth, Oregon,

of the Pacific Northwest Region 2546
of the United States.
I began my quest
as a nineteen-year-old
supercomputer programmer
that was also a night janitor
and a research mathematician-in-training.
My mathematical quest predated
the janitor-mathematician
in the Oscar winning movie
named “Good Will Hunting”
that solved
one of the toughest problems
in mathematics.
I was not on the cover
of top mathematics publications
because I was good looking.
I was on the cover
of top mathematics publications
because I contributed
to algebra and calculus
and contributed
to the existing body of

mathematical knowledge
that was written in algebra
and calculus textbooks,
namely, I invented
how to solve the toughest problems
arising in algebra and calculus

52.1.3 Breakthrough of Philip Emeagwali in Algebra

I did my supercomputer research
nearly every day, including Christmas Days.
For me, another public Eureka moment—
resolving the timer issue—occurred
during my **sixteen-hour marathon** of
massively parallel processing
supercomputing session
of the Christmas Day of 1989.
On that Christmas Day,
I was massively parallel processing **across**
my ensemble of 65,536 processors
and doing so in Los Alamos,
New Mexico, United States.

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I visualized and programmed
that new supercomputer
as a new **internet**
that I had theorized
as a new global network of
two-raised-to-power sixteen
tightly-coupled processors
that shared nothing with each other
and that were already available
in the market
and that is the fastest computer
de facto.
Earlier, on the Fourth of July 1989,
I **invented**
how to massively parallel process
my 64 binary thousand processors
that were within my new internet
and how to parallel program them
to compute together
and do so
as one cohesive, seamless supercomputer
that was the precursor
to the modern supercomputer.

Shortly after Christmas Day of 1989,
The Computer Society
of the IEEE
that was the world's largest
computer society
issued a press release
stating that I—**Philip Emeagwali**—
had achieved a breakthrough
in massively parallel processing
supercomputing.
The IEEE is the acronym
for the Institute
of Electrical and Electronics Engineers.
In the May 1990 issue
of the academic journal
named "Software,"
the Computer Society of the IEEE
described my experimental discovery
of the speedup
of the massively parallel processing
supercomputer
as follows:

[quote]
"The amount of money at stake
is staggering.
For example,
you can typically expect to recover
10 percent of a field's oil.
If you can improve your production schedule
to get just 1 percent more oil,
you will increase your yield
by $400 million."
[unquote]

That 1989 press release
that announced my experimental discovery
of the speed increases
from the massively parallel processing
supercomputer
and the companion article
published by the IEEE
led to cover stories
in mathematical publications
and to mathematical stories
on my mathematical inventions,

and, in particular, mathematical stories 2551
on my contributions
to new algebra and new calculus.
My contributions to algebra and calculus
was the front page story
of the June 1990 issue
of the *SIAM News*.
The *SIAM News*
is where news worthy discoveries
in research mathematics
are announced.
The *SIAM News*
is where new contributions to mathematics
are described by research mathematicians
and explained to research mathematicians.
The *SIAM News*
is where new contributions to mathematics
is recorded and archived
for the Society of Industrial
and Applied Mathematics
and archived for future generations
of research mathematicians.
My contributions

to computational mathematics
was also the headline stories
in newspapers **across**
the United States, Europe, and Africa.

52.1.4 Early Years in Algebra

Unlike the American or European
research mathematician and scientist,
I was never formally taught
how to do mathematical
and scientific research.
I did scientific research
at the science fair level
and at age 15 in June 1970
in my one-room study
that was near the intersection
of Venn Road,
and Iweka Road, Onitsha,
East Central State, Nigeria.
In 1972, the science column

of the *Daily Times*—that was then 2553
the national newspaper of Nigeria—
mentioned
a 17-year-old **Philip Emeagwali**
of Christ the King College,
Onitsha, East Central State, Nigeria.
In the United States, I began solving
the most extreme-scaled problems
arising in algebra
and arising from the discretization
of the partial differential equation
of modern calculus.
I began solving
those algebraic equations
on sequential processing
supercomputers.
I began solving
those extreme-scaled problems
on Thursday June 20, 1974
at 1800 SW Campus Way,
Corvallis, Oregon, United States.

Three weeks after 2554
I began supercomputing,
a newspaper that circulated in the cities
of Monmouth and Independence, Oregon,
United States,
published a photo
of a 19-year-old **Philip Emeagwali**
on its cover.
Looking back to the early 1970s,
I learned a lot in my first sixteen years,
onward of March 24, 1974,
in the United States.
But I also spent sixteen years
unlearning the sequential processing
supercomputing
that I **learned** from American
computer scientists.
I found my supercomputing vision
in the early 1980s
and I found it at the farthest frontier
of the massively parallel processing

supercomputer.
I learned that
the answers to the biggest questions
don't come easy.

52.1.5 Origin Story of Philip Emeagwali

I'm **Philip Emeagwali**.
My experimental discovery
of the massively parallel processing
supercomputer
was written **across**
major U.S. newspapers,
such as in the June 20, 1990 issue
of the *Wall Street Journal*.
That discovery of a new internet
that was a new supercomputer
and a new computer
was the exclamation mark
of my intellectual journey
that began in June 1970

and began in a bookstore
that was near **Zik's Roundabout**
in Onitsha, East Central State, Nigeria
and that was a shouting distance
from Dennis Memorial Grammar School,
Onitsha, Nigeria.
My mathematical journey
to the farthest frontier of calculus
began with the 568-page
blue hardbound book.
That book was titled:
"An Introduction
to the Infinitesimal Calculus."
That book was subtitled:
"With Applications
to Mechanics and Physics."
That book was written by
G.W. [George William] Caunt.
My scientific quest for new physics,
also began in June 1970
and began in Christ the King College,

Onitsha, Nigeria.
My scientific journey
to the frontier of knowledge
of the most extreme-scaled
computational physics
began with the one thousand
one hundred and eighteen
[1118]-page book
that was titled:
“Advanced Level Physics.”
That physics textbook was written
by Michael Nelkon and Philip Parker.
“Advanced Level Physics”
was the most popular physics textbook
across the British Commonwealth.
“Advanced Level Physics”
was widely used in Nigeria, India,
and the United Kingdom.
I spent the twenty years,
onward of June 1970,
mastering algebra and calculus

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and physics
and doing so to arrive at
the frontiers of knowledge
of algebra, calculus, and physics.
I spent those twenty years
trying to figure out
how to **solve**
previously **unsolved** problems
in calculus and in algebra
and in computing.
I spent those twenty years
researching
how to solve the toughest problems
arising in extreme-scale
computational physics
and, in particular, how to execute
their floating-point
arithmetical operations
and execute those operations
at **unheard of speeds**
and execute those calculations

across a new internet 2559
that is a new global network of
processors
that emulates
the fastest supercomputer.
I spent those twenty years
in quest for new frontiers
of technological knowledge.
I spent those twenty years
crossing those frontiers of knowledge.
I spent those twenty years
experimentally discovering
how to solve the toughest problems
that arose in the most extreme-scaled
computational physics.
The common denominator
of those grand challenge problems
in supercomputing
was that each problem
had the largest known
system of equations

of algebra 2560
at its computation-intensive
granite core.
That invention
of how to massively parallel process
and how to solve
the toughest problems
arising in calculus and algebra
—or how to process many things
(or processes) **at once**—
is my contribution
to the future editions of the textbooks
that I studied in 1970,
and to textbooks such as
“An Introduction
to the Infinitesimal Calculus”
that I studied in 1970
and to textbooks such as
“Advanced Level Physics”
that I also studied in 1970.

52.2 Philip Emeagwali Algorithm

52.2.1 Why Learn Algebra?

A Nigerian student asked me:
"Why do I have to learn algebra?"
I can give a thousand and one reasons
why algebra
should remain the recurring decimal
in the syllabus of the
West African Examination Council,
called **WAEC**.
Or why algebra should remain
in the syllabus of the Nigerian
Joint Admission Matriculation Board,
called **JAMB**.
The first reason
all Africans
should learn algebra
is that algebra

was invented in Africa 2562
and invented by African mathematicians.
The first quadratic equation
was first used in North Africa
and first used centuries before the birth
of Jesus Christ.
That is, the quadratic equation
is in the ancient algebra textbook
of ancient Africa.
So learning ancient algebra
for WAEC or JAMB examinations
is akin to
learning ancient African history
for WAEC or JAMB examinations
and is akin to learning
who you are
and what your African ancestors
contributed to mathematical knowledge.
Just as the baby must learn to crawl
before running,
ancient algebra

—such as the quadratic equation—
must be understood
before modern algebra—such as
solving the world's largest system
of equations
and solving them **across**
millions upon millions
of processors—
could be understood.
As the leader in the supercomputing
of tomorrow,
the modern algebra student in Nigeria
should be trained
to use her knowledge of modern algebra
to help grow Nigeria's economy,
and, in particular, to use her knowledge
of how to solve
the most extreme-scale problems
arising in modern algebra
and how to solve
those computation-intensive

mathematical problems
and solve them
in parallel, or by processing
many algebraic problems
(or algebraic processes) **at once**.
As the leader
in the mathematical sciences,
the modern algebra student in Africa
should be trained
on how to solve the toughest problems
arising in extreme-scaled algebra
and how to solve them
on the fastest
massively parallel processing
supercomputers
and how to use that knowledge of
modern algebra
to increase Nigeria's petroleum revenue.
As I explained in detail
in my lecture series that I posted at
emeagwali dot com,

a system of
zillions upon zillions
of equations of algebra
must be solved by each oil company
that is searching for crude oil and
natural gas
in Nigeria.
It is, in part, for that knowledge of
extreme-scale algebra,
that Shell Oil Company
keeps 40 percent
of Nigeria's oil revenue.
If Nigerians have the knowledge
of extreme-scale algebra
and as well as have the knowledge
of cutting-edge petroleum techniques
and technologies,
Nigeria will be on its way
to keeping one hundred percent
of its petroleum revenue.
Keeping one hundred percent,

instead of sixty percent, 2566
of petroleum revenues
effectively doubles Nigeria's
national wealth.
A young Nigerian asked me:
"Why must algebra
remain in the school syllabus
of Nigeria?"
My answer is that
the mastery of extreme-scale algebra
is needed to discover and recover
otherwise undiscoverable
and unrecoverable
crude oil and natural gas
from the Niger Delta region of
southeastern Nigeria.
Put differently,
the petroleum-based economy
of Nigeria
is in the hands of the
modern algebraist-**in-training,**

and in the hands of the 2567
nine-year-old Nigerian
that can only solve
the quadratic equation
of algebra.
Twenty years later,
that nine-year-old Nigerian,
could be solving
the most extreme-scaled problems
arising in algebra
and solving
those mathematical problems
to help Nigeria
use the massively parallel processing
supercomputer
to discover and recover
otherwise elusive
and unrecoverable crude oil
and natural gas.

52.2.2 Discoveries in Algebra

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In early 1964 and at age nine,
I was enrolled in
Saint John's Primary School,
Agbor, Midwest Region, Nigeria.
It was in 1964 and in Agbor (Nigeria)
that I learned the algorithm
for finding the
greatest common divisor.
But in our home
along Gbenoba Road, Agbor (Nigeria),
my father, Nnaemeka James Emeagwali,
taught me how to solve the quadratic
equation of algebra.
My father taught me algebra
using his high school algebra textbook
that was originally published
in 1932
in the United Kingdom.
My father used that algebra textbook

at Christ the King College, 2569
Onitsha,
in the British West African colony
of Nigeria.
Christ the King College
was a famous Irish high school
that my father attended
for the six years inclusive
from 1942 to '47.
That book titled "Advanced Algebra"
was written by
Clement Vavasor [C.V.] Durell.
I learned the quadratic equation
in 1964 from "School Certificate
Algebra."
I learned the quadratic equation
two decades after my father learned it
from Reverend Michael Flanagan
who also taught at Blackrock College,
Dublin, Ireland.
Blackrock College

is one of the most prestigious schools 2570
in Ireland.
Back in 1964 in Agbor, Nigeria,
I learned that solving
the quadratic equation
of algebra
has something in common
with cooking Egusi soup
that is Nigeria’s national dish.
Solving the quadratic equation
and cooking Egusi soup
both demands a foreknowledge
of the algorithm
for solving the quadratic equation
and for cooking
the Egusi soup, respectively.
At our outdoor kitchen
at Gbenoba Road,
Agbor, Midwest Region, Nigeria,
I learned the algorithm
for cooking Egusi soup.

That algorithm required a foreknowledge 2571
of the instruction
that instructs the cook
to add bitter leaf
at the beginning,
to add dried "mangala" meat
a few minutes later,
and to add fresh cat fish
towards the end.
As a research supercomputer scientist
in the United States,
I solved the toughest problems
that arose in extreme-scale algebra
and I solved them
in the step-by-step manner
that I cooked Egusi soup in Nigeria.
Each partial **difference** equation
of extreme-scaled algebra
that approximated
its companion
partial **differential** equation

of modern calculus 2572
that encoded a law of physics
and that I emailed
to each of my ensemble of
65,536 tightly-coupled processors
with each processor
operating its own operating system
and with each processor
having its own dedicated memory
that shared nothing with each other
was my precise set of instructions
that's a general solution
to my system of equations
of extreme-scale algebra
that approximated
my systems of equations
of modern calculus
that encoded a set of laws
of physics.
To push the frontier
of the fastest computer
and thus to experimentally discover

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a never-before-seen computer
was to harness
the massively parallel processing
supercomputer
and to use that technology
to show that the impossible-to-compute
is, in fact, possible-to-compute
and to do the impossible
at a time
everybody said that
parallel processing will forever remain
a huge waste of everybody's time.
In my vision of the 1970s
and '80s, to push the frontier
of human knowledge
of the fastest supercomputer
was to simultaneously harness
my 64 binary thousand
tightly-coupled processors
and to synchronously
process my 64 binary thousand problems

and to process those problems
in parallel.
What made the news headlines,
in 1989 and thereafter,
was that I experimentally discovered
how to process many things,
or processes, **at once**.
What made the news headlines
was that I experimentally discovered
how to communicate **synchronously**
and how to compute **simultaneously**
and how to do both
to enable a parallelized
extreme-scaled
computational physics code
to be used
to foresee the previously unforeseeable
motions of fluids
that enshroud the Earth.
What made the news headlines
was that I invented

how to solve the toughest problems 2575
arising in physics, calculus, and algebra.
I invented
how to solve the toughest problems
and how to solve those problems **across**
my ensemble of 65,536
tightly-coupled processors
that shared nothing with each other.
I invented
how to solve
those grand challenge problems
and how to solve them in **real-time**,
instead of taking a **life time**
to solve them.
For my invention
of the massively parallel processing
supercomputer,
I used a set of laws of physics
as my common denominator
across
each of my 64 binary thousand

commodity processors
that outlined my new internet
and defined that internet
as a new supercomputer
that is a new computer
and that is a new global network
of two-raised-to-power-sixteen
processors
that were already available
in the market.
I invented
the fastest massively parallel processing
supercomputer
that an oil company can use
to reduce the time-to-market,
such as the time between
the discovery of crude oil
and natural gas
in the Niger Delta Region
of southeastern Nigeria
and the recovery of that crude oil

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and natural gas.
A set of laws of physics
was common in my system
of partial differential equations
of modern calculus
that **evolved** through my system
of equations of extreme-scale algebra,
that **evolved**
through my set of
floating-point operations
of arithmetic,
that **evolved** through each
of my processors,
and that **evolved** through
my new internet.
I visualized my new internet
as my new global network
of 64 binary thousand
tightly-coupled, commodity processors,
or a global network of
as many identical computers.

52.2.3 Contributions of Philip Emeagwali to Algebra

Extreme-scale algebra
is at the mathematical foundation
of the excruciatingly-detailed
petroleum reservoir simulation
that, in turn, provides a
computational surrogate
for crude oil and natural gas
recovery scenarios.
Those recovery scenarios
enable the oil company
to discover and recover
otherwise elusive
and unrecoverable crude oil
and natural gas.
Until my invention
that occurred
on the Fourth of July 1989

and that occurred
in Los Alamos, New Mexico,
United States,
until that invention
the vector processing supercomputer
was the king
in the world of computers.
In the 1980s,
the vector processing supercomputer
was the king
of the computer performance hill
that was then under
one billion calculations per second.
My invention
of the massively parallel processing
supercomputer
dealt a massive blow,
dealt a massive heart attack,
from which the vector processing
supercomputer never fully recovered.
My invention

of the massively parallel processing 2580
supercomputer
gave supercomputer scientists
a powerful tool
to make scientific discoveries.
The dream invention
in the world of supercomputer research
is to invent how to make computers
extraordinarily fast.
For me, **Philip Emeagwali**,
that dream invention
became a reality
on the Fourth of July 1989.
That invention
validated the modern computer.

Philip Emeagwali, July 1974, age nineteen, Central Oregon, United States. A month earlier, I began programming the fastest and first supercomputer to be rated at one million instructions per second. That first supercomputer was at 1800 SW Campus Way, Corvallis, Oregon.