Much Ado----

October 9, 2006 dward B. Silberstein

What brilliant subtlety of Shakespearean criticism, authorship, or poetry is about to dazzle this distinguished audience? The answer: complete my title. To be brutally honest, this paper, like the Jerry Seinfeld television series, is actually about *nothing*……nil, zip, nada, naught, cipher, scratch, void….*Zero*!

Zero is powerful for many reasons. It is infinity's twin and opposite, paradoxical and troubling. This has been a very dangerous, even evil concept in our history. Consider the word "naughty", a euphemism my beloved wife will apply to that child who has most recently tried to destroy our house or to dismember the family pet. Its origin is fascinating, coming from the noun "nought" or "naught", meaning "the arithmetical character zero". The unpleasant, worthless connotations of zero present themselves in the word "naughty".

Consider the power of zero. Less than a decade ago the U.S.S. Yorktown, a premier guided missile cruiser of considerable sophistication, was stopped dead by zero. New software had just been sent to the cruiser which forced the Yorktown computers to divide by zero. The result: one heavily armed cruiser sitting dead in the water, rendering 80,000 horsepower utterly useless. Two days were required to undo the damage.

The concept of nothingness, of zero, once threatened a proof of the existence of God and was conceptually dismissed by the likes of Aristotle, a denial which at least partially paralyzed scientific inquiry for much of two millennia. The biggest questions in religion and science are still about nothingness and eternity. Issues surrounding the void still lead

us into the strangest places in the universe. So let's examine together the strange biography of zero, nothing, the void.

In the beginning who needed zero? No one, really. Remains of an upper paleolitihic wolf bone found in Czechoslovakia with carved notches suggest that early man was counting about 30,000 years ago. We certainly counted long before we wrote. The first attempts at writing were to keep records of material goods in fourth millennium (B.C.E.) Sumeria. They needed to know how many chickens got through the night with predators lurking about. How many sheep was that bride really worth? One had no need for a number that expresses the lack of something when counting objects. A thing is simply present or not. Irving Cohn and Fred Silver wrote the classic 1923 "Yes we have no bananas", not "We have zero bananas!" The presence or absence of such goods was obvious. We shall return to the accomplishments of the Sumerians and their Babylonian successors.

The ancient Egyptians were quite good at geometry. Imagine the disaster the pyramids might have looked like if they were not! They devised the first decimal system based on different symbols for 1, 10 and 100, so that a number like 253 would have two of the symbols for 100, five of the symbols for 10, and three of the unit symbols. Thus they formed the number 253. It was cumbersome, but while using it the Egyptians developed the first solar calendar, using a 10 day week, presumably because of their decimal system. (We don't know how long their weekends were, but one doesn't see a lot of partying in their wall painting!)

Because of the regularity of Nile flooding, the Egyptian landowner saw his property, and its boundaries, submerged with regularity, but he had to know what was really his

when the water receded so he could replant his fertile fields. This led to careful surveying and measuring, then computing the area of land one owned.

Stealing land was a very serious offense, and the newly deceased Egyptian had to swear to the gods, according to the Book of the Dead, that he hadn't cheated his neighbor out of land. This sin was comparable to murder, and the appropriate punishment in the afterlife was having one's heart fed to a horrific beast. I hate when that happens! The many different shapes of the fields required an exploration of plane geometry as well to calculate their areas, and it is likely that Pythagoras studied in Egypt and picked up a lot of axioms and corollaries that bedeviled us in high school. But the Egyptians were a practical people. No one there needed zero to measure his land. No one needed zero to count the days and hours of their calendar. So, while they were the inventors of practical geometry, the Egyptians never had a zero in their numerical system.

Enter the Greeks, the first great abstract thinkers, founders of philosophical schools which influenced Western thought for two millennia. They soon mastered Egyptian geometry and had a decimal system as well, which probably had Egyptian origins. Rather than using hieroglyphs or pictographs for numbers, the Greeks used letters, e.g. H *(eta*) for Heaton, 100, M *(mu*) for myriori, 10,000, the myriad, the biggest number in their system. Sometime before 500 B.C.E. the Greeks evolved a system requiring fewer symbols than the Egyptians, using their Phoenician-derived alphabet (although the Greeks were the first to write vowels), so that *alpha* equaled 1, *beta* 2, etc. Using their 24 letters, plus three new symbols, the first three Greek letters stood for the numbers 1-9, the next nine for 10, 20, 30….90, and the final 9 for 100, 200, …900. To write the number 78 the Egyptian surveyor would require 7 symbols for 10 and 8 symbols for 1,

placed after these. In contrast, the Greeks would only need one letter representing 70 *(omnicron*) and one for 8 *(theta)* placed to its right. It looks simple, but just pretend you are an Athenian high schooler trying to subtract and carry a number, when the number is really made of letters! How did they do this? Simple. They cheated. They changed the Greek number to its Babylonian counterpart, did the math, and retranslated the answer into the Greek number system (with letters). They never adopted the more flexible Eastern system. And the great Greek mathematicians never envisioned a zero in their numerical system either.

Remember your first encounter with Roman numerals, struggling to remember what D (500) and M (1000) stood for? The Roman system actually was a step back from the Greek, influenced by the Egyptians' cumbrous sets of symbols. We quickly learned those Roman numerals on the faces of our old school clocks in order to count the time to eagerly anticipated recess and dismissal. Where else do we see Roman numerals today? Give up? We see Roman numerals at the end of every movie we attend, used in order to indicate the year the movie was made, but also to be so difficult to decipher that film obsolescence is avoided. When those multiple M's, D's, C's, X's, V's and I's fly by at the end of the credits of an old, familiar movie, it's maddening not to have time to figure out the year. Who could forget that "Titanic" won the Academy Award in MCMXCVIII….. 1998?

Not only did the Romans regress in their numeric system relative to the Greeks, but they also never discovered zero. As intensely practical engineers, masters of concrete, capable of erecting extraordinary structures like the Pantheon, they didn't need a mathematical expression of nullity. So think back to your childhood days of deciphering

Roman numerals. What letter represented zero? The Romans ignored the issue or never thought about zero, about having nothing. The Roman way was to expand, to build, to acquire!

Meanwhile, back in the Middle East, sometime around the fifth or sixth century B.C.E., the Babylonians were still using a cuneiform system invented by their Sumerian predecessors some two millennia earlier, which, to make life even more complex, was based on both the numbers 10 and 60, a sexagesimal system. Ah, base 60! So the "new math" we suffered through with our kids wasn't really so new! In Babylonia a single wedge, which looks a bit like an angular wine glass, an upside down triangle sitting on a vertical line, its base, stood for one 1, two of them for two, etc. up to ten when we find a new symbol. But at 60 we're back to the wine glass/wedge, usually written larger than when it stood for 1. Unfortunately the Babylonians, unlike their Egyptian and Greek neighbors to the south and west, allowed one symbol to stand for several numbers. So that wedge described above, if placed in the second position from the right, what we would now call the "ten's "position", stood for 60, not one. And if the wedge was in the third position from the right, or our "hundred's position", it represented sixty 60's, or 3600. So the same wedge could stand for 1, 60, or 60x60, i.e. 3600, depending on its place. Context usually told the merchant what the wedges he was dealing with really represented. That's true for us today when we're told that a stadium hot dog is "three fifty", as contrasted with our reaction when the same "three fifty" comes out of the mouth of a Delta agent.

Do you see a problem coming? What does one do with two vertical wedges together, which could be 61 or 3601, depending on their location or place? A very wise but

anonymous Babylonian fixed the problem by inventing a placeholder mark, using two slanted wedges to show that there was nothing in a given column. Then a wedge/wedge combination was 61, one 60 plus one 1, while wedge/placeholder/wedge three columned number had to be sixty 60's, followed by the absence of any value in the placeholder column (representing numbers ranging from 1 to 59 60's), then a single wedge at the right of the construct which was now identified as 1, so the number becomes 60x60 plus 1 or 3601. Until one thinks hard about a system based on 60's as analogous to our own based on 10, this can be brain-rattling. But, for the first time in human history, there was a symbol for "no number". It did little more than facilitate digits falling in the right places, and was itself just a very humble digit, taking its meaning from the digit to its left, without any numerical value of its own. That concept of zero would take hundreds more years to be realized. The great creative thinking about zero would come from the East.

What was the Greek problem with the concept of zero? It appears that the linkage of zero with nothingness led to considerations about the void and chaos which were intolerable. In Greek mythology Darkness was the mother of (or coexistent with) Chaos, which gave rise to Gaia (Mother Earth) and Uranus (the Heavens). Gaia and Uranus began the procreative process which eventually filled the Greek pantheon with 3,673 offspring according to a massive, recently published (MMIII) genealogy of Greek gods. Emptiness and disorder were the primal state of the universe, and their reappearance would represent the end of the world, definitely not a heavenly state to be anticipated, but rather the destruction of everything. Zero represented that void, a concept which was unacceptable in a Greek conception of the universe created not just by myth but also mandated by some of the greatest thinkers of Greek and Hellenistic civilization,

Pythagoras (c. 578-c. 475 B.C.E.), Aristotle (c.384-322 B.C.E.) and Ptolemy (c.87 C.E. - c.168 C.E.). Without zero the growth of mathematics and science was stifled, and even the calendar suffered. However, before accepting zero, Western philosophers, theologians and scientists would have to agree on the destruction of the Greek universe.

Pythagoras was a remarkable but eccentric mathematical philosopher who concluded that all is number, that the connection between shapes and numbers was deep and mystical, and that the most beautiful number-shapes were sacred. He also believed in transmigration of the soul (including animals), which required strict vegetarianism, as you might be related to that chicken crossing the road.

Pythagoras is credited with inventing the musical scale, based on mathematical ratios of plucked strings. He finally concluded that there was some mystic interchangeability of music, numbers, and nature. For him, understanding the world (and universe) was simply a matter of understanding the ratios and proportions that controlled the beauty of music and mathematics. This led to the Pythagorean model of the universe. The earth, of course, sat at the center of everything, and the sun, moon, and planets all revolved in circular orbits around the earth, attached to transparent crystalline spheres. The ratios of these were orderly, and he was sure they made “the music of the spheres.”

Remember that the placeholder “zero”, appearing in Babylonian writings about 500 B.C.E., actually during the life of Pythagoras, stood for concepts the Greeks could not tolerate, the void, and its obverse, the infinite. The infinite threatened Aristotelians with the idea that it could make all motion impossible, while the concept of the void was not compatible with the nested universe described by Pythagoras, ratified by Aristotle, and refined by the Alexandrian astronomer Ptolemy. Aristotle did understand that the concept

of infinity might exist but dismissed it as just a concept, not a possible reality. Therefore, he reasoned, there could not in actuality be an infinite number of crystalline orbs with planets and stars attached. There had to be a final, or outer one holding the stars with no void beyond. The cosmos was therefore finite and filled with matter, not void. No one questioned what seemed to be a reasonable explanation of the earth's position in the heavens, with all the heavenly bodies rotating in a circular orbit around it, even though it did require some imaginative explanations by Ptolemy and others about retrogressive motion, since some planets appeared to move backwards every so often. This apparent phenomenon was finally explained by Johannes Kepler (1571-1630 C.E.) as due to the elliptical orbits of all the planets around the sun.

This Aristotelian, and thus authoritarian, line of reasoning became an important proof of the existence of God, so any doubt about the planets and stars moving around the stationary earth was heretical. Why was it heresy? Well, each sphere rotating around the immobile earth had to be moved by the larger sphere outside and around it. Since there could not be an infinite number of spheres, because Aristotle said so, there had to be a final, outer sphere, the one holding the stars. But this moved too. How could it? Well there *had* to be a Prime Mover, and there was only one candidate for that job in Aristotelian, and later in Christian thought, which accepted Aristotle unquestioningly….. God. So the motion of the heavens was caused by God, and questioning anything about this concept was not a very safe idea, even less than 400 years ago, as Galileo Galilei (1564-1642) discovered when he found himself, in 1633, under a sort of house arrest for the last nine years of his life.

Denial of the infinite also meant denying the existence of nullity, zero, the void, since the void implies the existence of infinity. Here's why. There are only two logical possibilities for the nature of the void and both implied the existence of the infinite. Either there is an infinite amount of the void, in which case infinity exists, or there is a finite amount of void, but since the void is simply lack of matter, there must then be an infinite amount of matter to make sure that the void doesn't go on forever, i.e., that there is only a finite amount of void. In both cases the existence of the void implies the existence of the infinite, so Aristotle's argument would be destroyed. But the Greeks still rejected zero, void, the infinite, and infinity. And because of the power of, or abhorrence of, zero, scientific progress was held back for the next two millennia.

Meanwhile, back in what is now Iraq, we recall that when we last saw our fetal, or unborn, zero, it was passively acting as a placeholder in the Babylonian system of numeration, and nothing more, useful----yes, but without a numerical value of its own. When Alexander the Great (356-323 B.C.E.), whom Aristotle tutored, stormed into India accompanied by Persian soldiers (who had themselves conquered and replaced our Babylonians), the concept of the placeholder symbol for "nothing" apparently came along. And it was then that Indian mathematicians first learned about this primitive but useful Babylonian zero concept. After one particularly bloody victory, Alexander's men refused to go any further. The general acquiesced to avoid a mutiny, leading his armies back to Persia. So Aristotle's ideas never had a chance to take root in India, quite a bit of good luck for the history of mathematics.

In India there was no fear of the void or the infinite, which were actually encompassed in the complexities of Hinduism, where it was understood that out of the

void the infinite was born, and that there were innumerable other universes. Here zero finally, in today's vernacular, "got a life." There is evidence from the writings of ancient Indian texts and of Syrian bishops that by the fifth century C.E. the Indian number system had been simplified to nine numerals, plus zero. Indian mathematicians looked at numbers in the abstract, not simply as attached to the area of a plot of Nile wheat waving in the brilliant sun, or as useful for counting a wandering sheep herd. To them, unlike the reality based Egyptians, Greeks, and Romans, zero, infinity, and even negative and so-called imaginary numbers came to have meaning.

These Indian investigators were the first to find that zero was a bizarre number. Multiplying any number by zero destroyed that number, turned it into nothing. And the problem of dividing by zero was, they decided, a doorway to the infinite. To explain this conclusion, envision the fraction x/y. As y, the denominator, gets smaller and smaller, approaching zero, the quotient x/y increases toward (positive) infinity. Trying to divide by zero has us agreeing with the late Red Buttons' patter, "Strange things are happening." For example, it is obvious to us that 1x0=0 and 2x0=0. Please put that equality in your mind's eye as 1x0=2x0. Putting a zero as a denominator under each side of the equality gives us (1x0)/0= (2x0)/0. Now let's factor out the zeros in numerator and denominator, just crossing them out. Having done this simple factoring operation, we have landed in Wonderland, for we have just shown that 1=2, and that's slightly troubling!

Meanwhile, back in the Indian subcontinent and moving forward to the seventh century C.E., a bloody attempt at the conquest of India had resumed, this time a thousand years after Alexander the Great, by the warriors of Islam, and continued for hundreds of years. One could argue, sadly, that the fighting never stopped. It was here, in India, that

Arab mathematicians learned about Indian numerals, and brought them back to the West, where they, erroneously, came to be called Arabic numerals.

In the etymology of a word we find clues to the history of its origin. The very name "zero" is redolent of its Indo-Arabic origins. The Sanskrit for zero was *sunya,* meaning empty, reminiscent of the Babylonian placeholder role for those two slanting wedges, where the concept of the placeholder zero first appeared. The Arabs translated this into *cifr,* also meaning "empty", which became, in the language of Western medieval scholars the Latin word *zephirus,* which also meant a very slight, barely perceptible breeze, a zephyr. In Italian this became *zefiro* and was shortened, in the Venetian dialect, to *zero.* Non-Italian mathematicians didn't change the word so much, and for them it became *cipher.* Zero was so important to this new set of numbers that some called the whole Arabic numeral system *cipher*. This became the verb "to cipher", to figure mathematically.

To track down the origin of the symbol 0 is more difficult. Greek astronomical tables employed the letter *omnicron* to stand for that Babylonian placeholder. Perhaps use of the first letter of *omnicron* was the origin of the 0, but it is not likely, since the symbol for *omnicron* also stood, as we have seen, for 70 in the Greek scheme of numbering with letters. Some suggest that the modern day 0 came from the first letter of the Greek word for nothing, *oude,* while others suggest its origin from the first letter of the almost worthless Greek coin, the *obol.* Other, more imaginative scholarly explanations are not entirely unreasonable. Imagine yourself as an estimable Greek poet involved in transactions where the coins or counters are placed in the sand for all to see. If you remove a coin to pay for your jug (or amphora, to stay classical) of wine and your loaf of

bread, a round O or 0 is left in the sand. Was this the zero one confronted when there was nothing left?

The calendar was another place where zero, or the lack of it, has wreaked, if not havoc, at least mass confusion. In the sixth century C.E. Pope John I drafted Dionysius Exiguus, a.k.a. Denis the Little (or Humble), to figure out when Easter, based on the Jewish lunar calendar, would appear in the Christian solar calendar for the next few hundred years. Looking back over previous tables he employed some arcane calculations to come up with the "fact" that the birth date of Jesus of Nazareth must have occurred 525 years before the year in which he was working, and it was he who gave us the phrase *Anno Domini*, A.D., now deemed not p.c. (politically correct) in academia which has replaced it with C.E. (Common Era). There was no year Zero in his concept of a calendar because one simply didn't count beginning with zero. We don't teach our kids to start with zero even today. That trouble maker Dionysius probably didn't even know about the concept, since his Roman, and subsequent Christian, heritage, you may recall, had no symbol for zero in its numerical system. And Indian/Arabic numeral system hadn't arrived in Europe yet.

Now we shift forward two hundred years. In 731 C.E., about as far as Dionysius' tables had projected forward for the date of Easter, an English monk decided to "do the math" himself. This latter monk, soon to be famous for his book one can still view in the Library of the British Museum, the *Ecclesiastical History of the English People,* was Bede, not yet declared venerable but presumably well on his way. The problem he created was based on his arbitrary decision to begin that history in 60 B.C.E., extending Dionysius' system backward. Without a zero in his arithmetical vocabulary, the year

before the year 1 C.E. had to be called 1 B.C.E. There should have been a year Zero, but not then! For historical accuracy, it should be noted that Jesus of Nazareth may have been born about 4 B.C.E., if there was really a "Massacre of the Innocents" (an event strangely found only in the Book of Matthew but not mentioned in the other three Gospels), ordered by Herod the Great, since Herod died in 4 B.C.E., but we must ignore that to keep the rest of our Western dating system straight.

Remember Y2K, when the rollover of the year 1999 to 2000 was predicted to cause the super computer glitch of all time. Well it was a memorable moment, and, astonishingly, even the official arbiter of the world's time, the Royal Observatory Greenwich, sponsored a grand celebration on the wrong date, December 31, 1999, which closed exactly a year later, just in time for the real third millennium to roll in. Confused? Remember that the year One ended at midnight on Dec. 31, 1 C.E. and the year 10 C.E. similarly ended at midnight, 10 C.E. Moving quickly forward, we can see that when the two thousandth year since it was believed that Jesus of Nazareth was born ended, that was midnight, Dec. 31, 2000, and the third millennium began at midnight plus a microsecond, on January 1, 2001.

But we really don't care. We love being around numbers with a lot of zeros. As a kid didn't you breathlessly and impatiently watch the car odometer for that memorable moment when 9,999 miles turned magically into that ten thousandth? At the end of December 31, 1999 the "great odometer in the sky" clicked forward, and all four numbers in our calendar changed simultaneously for only the second time in the Common Era!

Not many civilizations figured out that it was helpful to count their years from zero. The two this writer found were remarkably strange ones. The Mayans (c. 300-900 C.E.,

in the Yucatan peninsula) needed three calendars to prevent, they believed, the end of time, which, of course, would spell their end as well. The dangerous Mayan god to be feared at the end of time was, believe it or not, Lord Zero. The other was tragic, modern Cambodia, upon which Pol Pot and his collaborators inflicted horrific genocide, after which he planned to start all over with the year Zero as 1975!

Christianity rejected zero for a long time, but the reality of profit from trade demanded it. Leonardo of Pisa, a.k.a. Fibonacci (c. 1175-1250 C.E.), he of the famous numerical sequence relating to rabbit fertility (another story for another time), had traveled widely in North Africa and the Middle East, and brought back to Italy the "nine Indian figures….and the sign 0 with which any number may be written." Zero was still regarded as somehow different. Even today it follows, rather than preceding, the nine Arabic numerals on any key board or telephone dial. Merchants were enthusiastic about the new numerals but local governments were not. Too easily one number could be changed into another, e.g. turning 0 into 6 with a flick of the pen. Florence actually banned Arabic numerals in 1299 C.E., but merchants continued to use them, even sending secret messages in numerical code, which is why the word "cipher", standing for the 10 Arabic numerals, as you may recall, came to mean a secret code.

Finally one must acknowledge that zero is behind all the major dilemmas in modern physics. The strange density of a black hole results from a zero in the equations of general relativity, yielding infinite density. The infinite energy of the vacuum is the result of a zero in the mathematics of quantum theory. The postulated "big bang" of creation forces a consideration of zero such that, if the universe came from nothing, both relativity and quantum theory break down when physicists try to explain the origin of the cosmos.

Gentlemen, you may need to brace yourself for a meeting with zero. It may not be pleasant. You could be confronted by a zero in the current evaluation of last month's hottest stock, in your offspring's bank account, or, metaphorically, in the monumentally dull person, an absolute nothing, you just got stuck with at that cocktail party you really didn't want to attend anyway.

But console yourself. Think of its remarkable history, its spectacular pedigree. *And,* so, *for that zero, gentlemen, a little more respect please! Gentlemen, with glass raised, I give you..... Nothing!*

Bibliography

Boyer, Carl B. *A History of Mathematics* New York: John Wiley and Sons, 1968.

Gould, Stephen Jay. *Questioning the Millennium*. New York: Harmony Books, 1997.

Kaplan, Robert. *The Nothing That Is: A Natural History of Zero. O*xford: Oxford University Press, 1999.

Newman, Harold and Jon O. Newman. *A Genealogical Chart of Greek Mythology.* Chapel Hill, NC: The University of North Carolina Press, 1993.

Neugebauer, O. *The Exact Sciences in Antiquity*. New York: Dover Publications, 1969.

Seife, Charles. *Zero: The Biography of a Dangerous Idea*. New York: Penguin Group, 2000.