Part Two
Some Technical Innovations with Large Markets

Chapter 2

Computational Mathematics and Stories from Gus Kinzel

Upon finishing my thesis work and exploring what to do next, several problems in computational mathematics appeared to require certain novel approaches. My simple tech solutions to them may be useful for a variety of practical problems currently still engaging the conventional messy tech approaches.

Exact Numerical Solution to Differential Equations

This is by far the most important break among the three I listed numerical methods in this Chapter. Dicke of Princeton University proposed that if the core of the sun would rotate at an order of magnitude faster than the 25 days per revolution of its chromosphere as we observed, then the core mass would have such an oblate form whose non-spherical configuration could contribute up to 5% of planet Mercury's parahelium advances that are explained by general relativity. Planets circle the sun as a point gravitational source in elliptical orbit, with the fastest speed at the nearest distance. According to relativity, a higher speed implies a heavier mass, which is particularly true for Mercury, the sun's innermost planet. A heavier mass implies an added angular momentum in each approach to twist the trajectory of Mercury's elliptical orbit, thus Mercury's parahelium advancement. Indeed, the chromosphere is linked to the solar wind magnetically and the large scale torque could have caused the large scale differential rotations, as observed some what between the solar equator and the solar cap. Well, if the sun is not nearly perfectly spherical, which we are not sure, the planet Mercury has certainly a tidal distortion with a tidally locked surface facing the sun, just like our moon has a surface tidally locked by the Earth. S. Chandrasekhar of the U of Chicago did assign me to work out mathematically the tidal distortion of a liquid drop. The mathematics was exceedingly tedious without numerical inputs of a computer, and at the time I worked for Chandra I did not know how to use computer effectively for numerical analysis. With large computers available to me then, perhaps I could revisit this realistic and important problem; the tidal distortion and its contribution to relativistic corrections instead of focusing on an oblate solar core.

Before the tidal term could enter the equation, a very accurate orbital calculation must be established using numerical analysis with a computer. The conventional routine of resolving the differential equations, in fact until currently, is to change it to a series of difference equations with millions or billions of terms under the Runge-Kutta routine, for example, and string them up with a summation. To make each term of the finite difference more accurate, there are Newton's cut, Cauchy's cut, etc. that can be incorporated into the equation. But for the perihelium advances, the numerical accuracy required was far, far beyond what the correctional terms could provide.

Like any differential equation, once the perturbation term such as the tidal distortion has been incorporated into the equation, there is absolutely no hope of finding an exact solution, and the conventional numerical approaches by large computers are not sufficiently accurate to provide any useful result. Suddenly an idea of simple tech occurred. While messy differential equations cannot be solved to reach an analytical solution, they can always be differentiated into a higher order equation and be dealt with from there. This higher order can include all the perturbation terms such as the tidal distortion, thereby allowing the finite difference to be integrated in the higher order, with their exact solution being nothing but the original equation to get the problem started. I tried it, and it worked like a charm. Because now the solution is exact, the intervals for the finite difference can be made very large, from one boundary term to another. With this simple tech, a little program could enable any PC to overwhelm any super computer. With this method in mind, whenever I saw the users of large computers, who can be weather forecasters, airplane designers, or simulators for nuclear reactors or nuclear explosions, complain that their supercomputers are not sufficiently powerful for their needs, the chances are that they are only using the conventional finite difference routine without engaging the higher order approach, which is truly a simple tech with some obvious commercial potential. I did ask my son to generalize this approach into a Ph.D. thesis after he took a class in differential equations. He did not quite make it and my wife never forgave me for it, because he was then only a junior in high school.

Rearrange the Integral-Differential Equation of Bethe-Goldstone to Matrices and Vectors

The second break in that year was to solve nuclear potentials for the Bethe-Goldstone equation for nuclear matter calculations. As his post-doc, Bethe needed me to do some programming to help iterate various possible forms of nuclear potentials, tensor as well as scalar terms, to fit with the measured scattering phase shifts. With the use of one of the most powerful computers of the time, the nuclear computations did not just compute, they "burned" the computers at tens of hours per run. I changed Bethe's integral-differential equations into a set of coupled matrix-vector equations. By some simple matrix inversions, the potentials could be exactly solved for each set of the measured phase shift. I heard that this approach had troubled Bethe for many months before he would believe it, and it did lead to some thesis work directed by Bethe's associates. But my involvement in nuclear matter calculations at Cornell lasted for only three months.

Monte Carlo Simulations

My third encounter on the numerical simulations was also a programming task. I got a post-doc job to deal with solar wind data at MIT. The astrophysics group there had 3 solar wind satellites, and owned one-third of a very large computer. Nuclear physics had the other two-thirds, all being part of the Physics Department. But for every minute of a satellite's flying time, its data would require more than a minute of computer time to analyze. Three satellites, one-third of a giant computer, implies that there is a lack of computer power by a factor of ten. My initial appointment at MIT was only one-year, and there were more than twenty man-years of programming work on the project already. If I worked very hard to learn the previous programming work and improve upon them, I might be able to extend the appointment, but this was highly unattractive. On the other hand, all satellites for solar wind are built alike, and all solar wind propagations are similar. There are six variables in the solar wind parameters that needed to be sorted out, so I systematically varied all the six variables under a Monte Carlo routine, complied a six-dimensional data matrix, and by altering a seed random number, the data library can be calibrated against itself for accuracy. The library data was found to have an accuracy of ~1%, which was an order of magnitude more accurate than the engineering measurements. As a result, this library was perfect for data analysis. While the computer was exceedingly slow to follow each and every charged particle to travel through the Faraday Cup of the satellite, the computer was very fast in interpolating the library data; it could analyze a year of recorded satellite data in 3 seconds, an improvement of 10^7. I worked myself out of a job in 3 months, and began teaching.

There are many instruments or devices similar to satellites; nuclear reactors, for example, do not need to recalculate all the neutron flux if some design parts are altered or replaced; airplanes and cars are often very similar from one generation to another, and their simulated performance should involve only minor variation with similar parameters while allowing the same performance functions. The key here is to think through the problem at hand and sense what the solution should be prior to getting busy on the tack. This change of a messy tech to a simple tech can be fun as well as rewarding. I did have a lucky year in computational mathematics.

Upon joining the faculty, I focused on the equation of state for matters at nuclear density and beyond. This equation of state enables one to calculate various parameters of neutron stars. With a very stiff repulsive nuclear potential, the neutron star could sustain ~2.5 solar mass before collapsing into a black hole. With an interactive softer repulsive core, the neutron star could sustain only a little more than one solar mass. The fact that π meson would appear spontaneously under 140MeV, the nuclear core cannot be too stiff. Stiffness of the nuclear core is not too important for nuclear matter in atomic nucleus, but it is vitally important to neutron stars. I felt that the core could not be too stiff, contrary to Bethe's nuclear potential. In the recent "Chandra X-ray Observatory" measuring the X-ray sub-pulsing rate of the pulsars, whose rate, assuming a break of mass addition from the event horizon can be linked to the neutron star mass, almost all of them are of approximately around 10 kilohertz, implying for a light one solar mass. I am very grateful to see these measurements after being away from the field for 35 years. A small limiting mass of neutron star, in a multi star system, could readily gain mass from its companion star(s) and thereby collapse or fly apart just like what we observed in the Type IIa supernovae from white dwarfs. The collapse of neutron stars would likely involve gamma rays under very short bursts as compared to Type IIa supernovae emissions over a couple of weeks. Since we observe the 10 second gamma ray bursters daily and with a uniform distribution the cosmos, these galactic events may imply that there are far more collapsing small neutron stars and black holes than we realize.

Some Stories from Gus Kinzel.

Augustus Braun Kinzel was born in 1900 on the Braun dairy farm in

Manhattan where currently is the location of Rockefeller University and New York Hospital/Cornell Medical College. He was the oldest of three brothers, and his younger brothers would tease him that the chimney of the house where Gus was born had never stopped emitting hot air. When I told the rental agent that our R and D laboratory would have the emission of hot air as a manufactured product, it was meant to be a continuation of the Kinzel tradition. After all, our laboratory was also on the location of the former Braun dairy farm.

Gus was a member of the board of management at MIT, together with Thomas J. Watson, Jr. then CEO of IBM. As some faculty members of MIT objected to the school's linking with IBM, Watson resigned from the MIT board, joined the Cal Tech board and took Gus with him as they were close friends over a long time. Gus was a wonderful story teller, and I shall share some of his stories here.

In his early thirties at Union Carbide, Gus was asked by the CEO to be their chief scientist. He refused. When asked why, he answered that the job had no power, and without power, he could not get much done. So he was given the veto power of divisional budgets. He wanted to organize a centralized research laboratory; particularly for the graphite fibers as its technology had matured sufficiently to serve many industrial applications and Union Carbide could be the leader if the development was properly carried out. He wanted the researchers of the graphite division to relocate to the new research center at Elmsford, New York. But the division head insisted that the researchers were very important to his sales and could not share them with the new research center. Gus re-assigned all the researchers there to marketing and started the research center without them. His action did hurt many career scientists, but he maintained that the circumstance at that time warranted these actions.

Establishing the Courant Institute

Gus wanted to establish an Institute for Applied Mathematics at NYU under Courant, his close friend and fellow member of the National Academy of Sciences. He went to Alfred Sloan for funding. Sloan said that he would look into it if it merited his support, and told Gus that indeed it would be a good project. But Sloan had already promised Warren Weaver of Princeton to establish a mathematics institute. Gus argued that the Courant case was more urgent. But Sloan would not yield because he had promised Weaver to be next. After all, "it is my money" Sloan said. Gus still insisted to do the Courant first and Sloan would not receive him any more. Finally, Gus asked for an appointment to talk on an issue other than the Courant funding. Sloan agreed.

"You are not coming to waste my time to talk on the Courant funding, aren't you?" Sloan asked.

"No, I won't talk abut the Courant funding." Gus answered.

"How can I help you, Gus?"

"I have the most difficult problem. Suppose the Courant funding is there, how could I name the building of the Courant Institute?" Gus asked.

At this point, Sloan laughed and said.

"Okay, Okay, Gus, you win, you win." and gave up.

So today, the building of the Courant Institute is called the Warren Weaver Hall. No one ever named a University building without paying for it. Gus gave the privilege to Sloan to name the building and of course, the bill went with the privilege and Weaver missed out on an Institute. In a memorial service for Kinzel at Courant Institute, Gus' granddaughter asked me, as his last partner, to say a few words. I told this funding story. Many board members of the Courant Institute were there, including Dr. C.N. Yang, our most well known Chinese physicist.

Gus' Famous Tie

Gus had 4 daughters, all married in the same year. After Mrs. Kinzel died, Gus promised himself that he would not get married again because he was very close to his wife. He did have many girlfriends. One of his daughters stitched all his girl friends' name on a red silk tie; over twenty of them, and most of them all knew each other. Gus would wear this red tie proudly during the Christmas-New Year holidays. His last girlfriend was Martha, whose name was not on the tie. At the memorial service at Courant, we met Martha in the elevator going to the top floor. Martha was telling us the distribution of Kinzel's estate; who got the stocks, who got the various real estates, etc. When my wife asked Martha who got this famous red tie, Martha answered, "Of course I keep it". We felt a little strange on the strong affirmative voice. "What's the big deal, I have more boy friends than he had girl friends." Gus and his friends were mostly older than seventy, and linking all his close friends together and keeping in touch was indeed a very comforting association.

Several Other Stories From Gus

When President Eisenhower died, he went to heaven. The Angels checked him out and awarded him a Cadillac. When President Truman died, he went to heaven and the Angels awarded him a Rolls Royse. One day Eisenhower saw Truman was cursing next to his stopped Rolls. “What’s going on, Harry”, Ike asked. “Those damm Kennedys and their tricycles”.

Dr. Augustus B. Kinzel

An Absent Minded Institute Professor

Norbert Wiener was a well-known absent minded mathematician, an Institute Professor at MIT and “the father of computer sciences”. From his office to the cafeteria, he had to walk across a quadrangle in the campus and various people, students, research associates, and faculty members would stop him and chat with him, sometimes the chat grew to a small group. By the end of the conversation, Dr. Wiener would invariably ask, “Where did I come from?”. If from the office, he would go to lunch. If from the cafeteria, he would go back to his office. In such a routine, one of his colleagues tricked him, knowing that he had lunch already, told him he came from his office, and in order to see if he would go for lunch again. He did.

Mrs. Wiener took complete charge of the household details and of the family. One day she told the husband,

"Norbert, we will be moving today. Come home to the new apartment and not the old apartment."

"Yes dear." he answered.

"In case you forget, I have stitched the new apartment address on top of your jacket's inside pocket."

"Yes dear"

By the end of the day, Wiener went to the old apartment. It was empty, the family had moved. He had remembered, but had no idea where. He forgot also the address in his jacket. Then he saw a girl running toward him. He asked,

"Little girl, little girl, do you know where did this family go?"

The little girl shouted "Daddy, Daddy, Mommy sent me to fetch you."

And this little girl was their only child, Peggy. I did try to train myself to focus and concentrate, but could never reach the level of Norbert Wiener, and therefore most of my missions or work are not accomplished.

Kinzel at the Manhattan Project

While Gus was working on the Manhattan Project, workers would enter the gate with a password. There was no identification. Once after traveling for several days, the password had changed and Gus could not pass through the gate. It was midnight and the sergeant whom Gus knew was off-duty and not at home, while the guard did not know him and would not let him in. So Gus "crushed the gate", and made the guard arrest him so that he could spend the night in the jailhouse which he built. The jail had a warm blanket etc. and it was free and very comfortable.

There were many young scientists at the Manhattan Project at Los Alamos, a primitive location in New Mexico at that time. The scientists were mostly in their childbearing age so the group had a very high birth rate. But the place had no facility to accommodate babies. One day General Gaven told Oppie (Oppenheimer) and Gus that there were so many new born that they must do something about it. Oppie acknowledged “yes general, yes general”, while Gus was laughing sick without showing, because Mrs. Oppenheimer was also expecting their first born.

Over the 15 years of partnership with Kinzel, he shared many managerial stories or observations with me. There are climbers in any big corporation, but some would know or pay attention to only those ahead of them and pay no attention to those behind. Those executives reached to the top position, they could suddenly become a stranger to the company by knowing almost no one, except perhaps the doorman.

There are always politics and in-fights in any institution, some worse than others. For professional politicians, their fights and struggles are often worse than companies’ and become a “blood spot” where the losers simply “die”. But, Kinzel observed, the singular example of the worst politics occur in academic institutions, where the fights can be so brutal because the stakes involved are so low. I recalled that once I had lunch with the dean of a leading university who was formally an executive under our chairman Fred Seitz. I asked him whether his faculty members have gatherings for lunch often. “No, no”, he answered, “they would worry to have poison in the soup”. Indeed, it’s difficult to function properly in such a hostile environment, a situation which most students do not aware.

CHAPTER TWO FOOTNOTES

2.1) Robert Dicke (1916-1997),

Robert Dicke, professor of physics at Princeton University. A famous story attributed to his work goes as follows: Hubble’s observation of the expanding universe led to the big bang twenty billion years ago, according to the Hubble’s constant at that time, that started the universe. The big band would cool during its expansion, and became transparent to photons at approximately 3,000ºK. These relic photons may be red shifted to only a few degrees K and be observable today as the mm “background” microwave signal. Since no one has seen this microwave signal, Dicke had organized a team to experimentally detect it. Then he received a phone call from Arno Penzias (and Robert Wilson) of the then Bell Labs about their puzzled microwave background, which was precisely what Dicke was looking for. Upon hearing the Bell Lab observation, Dicke announced to his team: "Boys, we have been scooped". Penzias and Wilson did share one-half of the physics Nobel in 1978, with the other half awarded to Pyotr Kapitsa (1894-1984), a very prominent Russian physicist in low temperature physics.

On the pear-shaped tidal distortion of the planet Mercury, it has two correctional teams to its orbit, with the near-sun term being additive and the far side term being subtractive. To the first order, these two terms would cancel each other out while Dicke's oblate assumption of the Sun does provide a net additive term to the Mercury orbit from the spherical solar shape.

2.2) On numerical analysis of differential equations, take the first order ordinary differential equation as an example,

$$y' = f(x,y)$$

under finite differences,

$$y_{n+1} = y_{n-1} + 2hy'_n + O(h^3),$$

with h the small increment as Δx.

If the function f(x,y) denotes the change of trajectory of an ellipse, for example, then each tangential projection or y'(x,y) will be under projected, regardless of how small is the increment h, leading to the total error $O(h^3)$ being cumulative even if a super-computer with billions and billions of very small cuts is used, the analysis would still deliver a large cumulative error.

Alternatively, from y' = f(x,y), a higher order

$$y'' = g(x,y)$$

can also be used for the finite difference equation. Under the Runge-Kutta routine of second order difference equation for example, the term y_{n+1} for the second order becomes

$$y_{n+1} = y_n + ½ (k_1 + k_2) + O(h^3)$$

with $k_1 = hg(x_n, y_n)$

and $k_2 = hg(x_n+h, y_n+k_1)$.

The fact that the second order traces functionally the changes of the first order, the increment h can be made from one specified boundary point to another and still obtain far more accurate result. In the "Prediction" and "Correction" analysis, when the higher order differential terms are involved, the error for each term reduces to the fifth order, or $O(h^5)$.

2.3) Richard Courant (1888-1972)

Dr. Courant was of Jewish decent. He came to the New York University in 1934 as a visiting professor, having left his position as Director of Mathematics Institute at the University of Göttingen in Germany. He was married to Nerina Rounge, daughter of Carl Rounge, a professor of applied mathematics at the U. of Göttingen

At NYU, Courant initiated, with some of his colleagues at the department, many war-related mathematical programs supported by the Office of Scientific Research and Development. Many of the said R and D programs moved to the Office of Naval Research. Courant's group was also supported by the Atomic Energy Commission, which was merged into the Department of Energy. Courant's activities spread all over the NYU campus and indeed they urgently needed a centralized location, which was the situation for Kinzel to tell Alfred Sloan that the Weaver Institute was less urgent and could wait. The Warren Weaver Hall for the Courant Institute was completed in 1965, after Courant's retirement. For the building Alfred Sloan provided the building construction and he asked his friend to provide a reserve fund for building facilities and other necessary supports for the Institute.

2.4) Alfred P. Sloan (1875-1966)

Alfred P. Sloan was the president and CEO of the General Motors where he established the planned obsolescence with annual styling changes. He joined the United Motor Company, the predecessor of GM, which bought his Hyatt Roller Bearing Company in 1916, became its VP in 1923 and its Chairman in 1937.

He graduated from MIT in 1895, established his Alfred P. Sloan Foundation for philanthropic activities in 1934. Until 2005, the said foundation still had assets of $1.5 billion. He used his GM fortune for philanthropy methodically that lasted over 3 decades, and organized many major Institutes that bear his name. They include the Sloan School of Management at MIT, the Sloan-Kettering Cancer Center of New York City etc. He also funded Institutes that do not bear his name, such as the Courant Institute, which was solicited by Gus Kinzel, although the Weaver Institute of Princeton never did materialize, except for the Warren Weaver Hall at NYU.

CHAPTER TWO REFERENCES

On the Runge-Kutta Routine

See Handbook of Mathematical Functions, by the National Institute of Science and Technology, Dept. of Energy, USA.