FORTUNE EIGHT
Aerospace Industries, Inc.
International Technical Services

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MEMORANDUM

To: CMA Class

From: Chauncey Uphoff

Subject: Class Notes for Lecture #15 (The last lecture)

Course Summary:

In this course, I have tried to teach what one cannot get from books or formal papers. I have emphasized the connection between the right brain (the part that feels good when you get the solution) and the left brain (the part that does the analysis and articulation). Of more long-term importance is my emphasis on learning to teach oneself.

I have tried to relate my own invaluable experience of learning astrodynamics at a time when there were few courses in astrodynamics and, while I had many good teachers, I had to teach myself most of what I know. That talent, whether God-given, taught, or learned, is what permits me to put the ideas of others together to obtain something that is new and right. This is how all Knowledge advances. I have tried, I think somewhat successfully, to communicate this concept to the class, along with the importance of acknowledging one's inputs. Nothing comes from nothing.

I have emphasized the concept of learning to think "backwards" in problems that seem intractable and have given several examples in my paper "Uncommon Sense in Orbit Mechanics." I taught the students "the cork trick," taught to me by Dr. Steve Bayliss. It is one of those problems that is easier to solve backward than forward and shows the value of reverse thinking and analysis. One of the homework problems was to solve a problem I had done previously, but in reverse, that is -- to start with my solution and work backwards to my premises. Some of the students found a fundamental error in my paper (see "I was Wr-Wr-Wrong in the Bonus Handouts on the website).

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Part of my (learned and self-taught) process of teaching is to pose the problems (both technical and political) with which I have been confronted during my career, and to tell "war stories" of how I (or my colleagues and I) have, or have not, solved them. I have been criticized often for telling these important "war stories." It's the only way I know, to teach how I put ideas together to get new ideas. That's the part one cannot get from books. Some of you "got it." Others will get it later as you realize the richness of the Physics from which we all derive our Knowledge, our Intuition, and, ultimately, our Freedom.

Perhaps the most important part of the war stories is that I have shown what I did wrong as I tried to solve the problems I have solved (or not solved). In some cases, I'm still not sure what I did wrong. This is to teach the students the kinds of things *not* to do so that you won't make the same mistakes I made. Thank you for your attention and your diligence; this was a very good group of students. I learned a great deal; teachers always learn more than students.

In the following paragraphs, I shall revert to my normal lecture notes style of a chronological description of the lecture. First I gave a short discussion of the answer to the course question. One of the students got the answer right.

The Course Question:

The question is:

> "How is it possible to describe the Universe if the description itself is to be part of the Universe we hope to describe?"

I am grateful to my professors John Mulhern, Robert Houston, and Sydney Butler for inputs that allowed me to ask this question. It came to me during my studies of quantum mechanics and the Heisenberg uncertainty principle.

I gave a hint to the answer during one of the lectures when I discussed the differential equation $dy/dx = y(x)$ and asked the student to imagine herself or himself the first person to be confronted with this problem. One might say "Wait a minute, you mean I have to know the function to get the derivative and I have to know the derivative to get the function but I don't know that either? You can't do that, it's a circular process." It does seem to be the "ham and eggs" problem described by the epithet "If we had some ham, we could have some ham and eggs, if we had some eggs."

But we all know that $y = e^x$. How did we learn that? We know that only because someone differentiated e^x and found that this function is its own derivative. As I recall, I described this by asking how we know that $\int dy/y$ is ln(y). The left-brain "formula" for integrating polynomials breaks down if the exponent is –1.

My three-word answer to the question is "trial and error." The one student who got this answer right used the expression "some kind of iterative process." Exactly right; it is the iterative process of finding a function (or description) whose derivative (or effect upon the Universe) satisfies the differential equation (or describes the real Universe with itself included). The one-word answer is "integration."

Integration is a right-brain activity because it includes "guessing" the answer and checking (with the left-brain) to see if it works. It is rather like doing a jig-saw puzzle, where one has to look at all the pieces and find the one piece that fits where one is trying to find a fit. But jigsaw puzzles have a finite number of pieces and are much easier to solve than (non-linear) differential equations that have an infinite number of potential solutions. That's why we resort to perturbation theories, in celestial mechanics, that expand the disturbing function in an infinite series of functions we already know how to integrate. But the answers are "out there;" we simply don't yet know the functions, which when differentiated, will satisfy the equations Professors Newton and Einstein "guessed," those that they and others later proved to be right.

This process of "educated guessing" and later verification is, in itself, an infinite process. As Professor Galambos said, "The amount of available knowledge is infinite." Notice that he did *not* say the amount of storable knowledge is infinite. But it might be, if the Universe has infinite mass or another infinite mechanism for storing information. That's something we don't know. But we can think about that possibility, which I consider a proof of Professor Galambos's thesis. As he said "There is no unemployment in Science." Every problem solved generates more questions than the answers obtained.

There is more to the course question. The near-certainty (in my opinion) that the correct description of the Universe will affect it implies that the description will change the Universe itself and, perhaps, even the laws of Nature that we now think of as "Laws." This is the heavy part of the question and its plausible answer.

My thesis is that the knowledge (information) in a confined region of space-time may change the very nature (or structure) of the space-time itself. If this thesis is valid, it will almost certainly be valid universally. This concept, if correct, will probably be true for all Universes (the Whole of which ours may be only an infinitesimal part).

Through what mechanism might the description of the Universe affect that Universe itself and/or the laws that we think of as Laws? I submit, ladies and gentlemen, that the mechanism may come from the "negative entropy" of "Information" and "Life." Professor Schroëdinger gave a good (but incomplete) definition of "Life" in his book "What is Life, Mind, and Matter?" (This may have been two books bound as one). If the students are interested in this definition, they should dig out the book; it will give you a good hint at what I'm saying.

I believe (my opinion) that the density of Life and Knowledge within a given domain of Space/Time/?/?/?/ … may reverse the increase of the entropy of the Universe we now "know" as the Second Law of Thermodynamics. If that thesis is correct, "negative entropy" may stabilize the Universe, Life, and Knowledge contained within the Universe and any sub-Universes thereof.

There were several other items, which included:

- The Triple Lunar Swingby No-Third. This is the TLS discussed in my Uncommon Sense paper but without the third lunar swingby. That swingby is replaced with a final injection burn near the low perigee of an already hyperbolic trajectory. I recently showed that this mechanism gains about 8 to 10% useful mass over conventional methods for transfer to Mars by using the 3 to 4 month angular momentum reversal of the TLS.

- A movie of the 15 spacecraft constellation in heliocentric orbit from my paper with Rich Reinert called "Space Physics Explorers." The idea is to build a number of nearly identical spacecraft and blast them into identical 0.4 x 1.0 au. orbits but rotated out of phase with each other. The pattern suggested forms the spacecraft into three concentric circles of 5 spacecraft each, equally distributed around the ecliptic and alternately moving from 1 au to 0.4 au and back to Earth's orbit. This would permit a separation of the spatial and temporal variations in the solar wind. (If I forgot to post this paper to Bonus Handouts, see my résumé for the reference.)

- A movie of Jerry Wright's solar sail trajectory to rendezvous with Halley's comet. This trajectory is discussed at some length in my Uncommon Sense paper. It's an example of a "backwards" idea and is one of the greatest innovations of the space program. Unfortunately, the Shuttle wasn't ready in time for the 1985 apparition and the Halley rendezvous program was killed by bureaucratic wrangling. Many of us, including Bruce Murray, then Director of JPL, were very disappointed and frustrated with the system. It seemed that, no matter how good our ideas, we could never get anything innovative through the pre-project phase. Many of us gave up on NASA after that. But things do happen, however slowly. The solar sail is making a comeback and the Planetary Society is building and launching what will be the first operational solar sail in this part of the galaxy. I warned the students not to give up when these things happen but to expect frustration and often depression if they're going to work in the "space biz," especially if they want to try anything new. NASA is studying the solar sail again now.

- There followed a short discussion of advanced propulsion technology such as SEP/NEP and anti-matter rockets along with my opinion of why "we" can't go to the nearest stars. The reason is that a trip to even Alpha Centauri would require tens of thousands of years at speeds that would keep the ship safe from micrometeorite impacts. One might say, "why don't we send many generations of explorers on a very large ship?" I say that we do not yet have the social technology that will permit the "travelers" to keep from killing each other or themselves. I pointed out that no "civilization" in our history has lasted more than about 500 years and that we all keep making the same mistake over and over. As Professor

Galambos said, in essence, "Ladies and Gentlemen, stop coercing each other." I mentioned Professor Galambos's book "Sic Itur Ad Astra" (This is the right way to go to the stars.) The book is available through TUSPCO on the web and is quite expensive; he intended it to be that way so he shouldn't have to deal with "Mr. Linus's business" as Professor Newton said when his theory was under attack from covetous "critics." I did not include very much of Galambos's Theory in this course; we had an agreement that he wouldn't do Earth-to-moon trajectories and I wouldn't try to teach his Theory of Volition. Besides that, it's very politically incorrect. But it exists and it's Right. But remember, as AJG said, "There is no such thing as instant smart." I ended the last lecture as he did for one of his lecture series – a picture of Andromeda galaxy and quoted him as saying "Isn't this a loftier goal (than trying to kill people who are not like you)?"

I had intended to write a critique of your homework problems and those technical problems most of you had. But I've said enough here and I've graded and returned most of the homework; if you have questions, please call me (303) 652-3591 or e-mail to <chauncey@oneimage.com>. Thank you all, and thanks and Gratitude to my mentors; they are now your mentors.

Best regards,

Chauncey Uphoff 2002 May 27