**Otto Neugebauer Raps My Knuckles**

Some years back I used to have lunch fairly regularly with the famous Austrian-American historian of mathematics and science Otto Neugebauer.I was an "honorary member" of the History of Mathematics Department at Brown University. We were joined at lunch , off and on, by other members of the Department that might include Abraham Sachs, David Pingree, Gerald Toomer and "visiting firemen" such as Bernard Goldstein and Noel Swerdlow.

I have written about these lunches in *Otto Neugebauer: Reminiscences and Appreciation ,* American Mathematical Monthly, Vol 101, Feb. 1994, pp. 129-131.

During these lunches Neugebauer talked freely about personalities, methodologies, history, politics, etc. He wore his prejudices "on his sleeve." Philosophy was a tabu subject. In the first place Neugebauer hated philosophy and philosophers, and secondly, insofar as he had formulated a philosophy of mathematics, it was in considerable opposition to mine But as regards the history of mathematics and science, I sat at his feet.

One lunch I happened to suggest that Ptolemy' s model of the solar system with its cycles and epicycles was an early and interesting example of curve fitting by means of trigonometric series. (eiө = cos(ө) +i sin(ө) ).This thought came to me through my work on approximation theory; but in point of fact I had heard it much earlier from another man whom I admired greatly: in the lectures of the physicist and philosopher of science Philipp Frank.

Neugebauer bridled at my suggestion. "No! No! No! I will explain to you what Ptolemy was up to." And he got up and left the lunch group. A few days later, I received a two page hand-written letter from him explaining in detail "what Ptolemy was up to." I was touched that Neugebauer took the time off to write to me and felt it was another indication of his total devotion to his historic craft as well as of his regard for me. The knuckle rapping led to no diminution of our friendship. Our lunch meetings continued, and my wife and I visited him and his daughter several times in their summer home on Deer Island in the Penobscot Bay, Maine area.

Recently in clearing out one of my drawers, I found his letter to me and I think that the mathematical community might find both this story and the letter interesting aspects of a major mathematical personality. I reproduce both a photo copy of the letter as well as a transcription. Notice that his signature is the backside of an elephant , its tail in the form of the letter "e." In his circles, Neugebauer, was known as "The Elephant" and I never once heard his colleagues refer to him in his presence as Otto or Prof. Neugebauer. Always: "The Elephant."

Ptolemy - but no Curve-Fitting

1. Let us assume that all planets move with uniform angular velocity in circles about the sun.

2. To test this assumption by "observation ", we must transfer heliocentric coordinates to geocentric. Or hypothesis is then represented by an epicycle model. There is nothing "good" or "bad" about an epicyclic model (which, incidentally, gives a very reasonable estimate for the distances of the planets from the ratios of the epicycle radii.)

3. A qualitative recording of the planetary orbits (during, say, 60 years for

[astronomical symbol the planet Saturn ] and [astronomical symbol for the planet Jupiter] ) supports strongly the existence of epicycles, seen edge on and moving along a slightly inclined deferent (cf.Fig 155 p.1255 in my "Hist.Anc.Math. Astron.") Cf. the view of galaxies in Kant -Laplace !

4. As a result of very sophisticated observations (perhaps in part based on Babylonian arithmetical models !) Hipparchus and Ptolemy found deviations from the uniformity of motion. It turned out that the simple device of assuming eccentric orbits (as in the solar theory) did not suffice. Ptolemy found the ingenious way out by assuming uniformity of angular motion about a point E (the "equant") symmetric to the observer O. But nowhere in his theory is a second epicycle used,

[Figure attached.] "Deferent" = circle about M.

5. Copernicus with his dogma of a) uniform b) circular motions (therefore about the mean sun, not the true sun !) used some 48 circles for the 7 planets (Ptolemy 2\*7 =14 !).

He eliminated the equant.

As far as I know the story about the epicycle-epicycles became "common knowledge" through a remark of Cardinal Belarmine in the time of the Galileo trials. I have no accurate reference at hand but substantially he said "let them (the astronomers) put epicycles upon epicycles, but they must keep their hands off from theology."

6. Kepler reintroduced the equant (also for the solar theory- i.e. for the earth's motion.), the he realized that the remaining small observational effects can be eliminated by replacing the motion about the equant by the equal-area theorem, and finally by replacing the circular by an elliptic motion with the foci replacing the two symmetroc centers O and E and the sun in one focus.

7. Newton explained the Kepler motion as the consequence of a dynamic law of gravitation.

P.S. The only "curve-fitting" in this story are Copernicus' rather inept attempts to approximate the Ptolemaic model as closely as possible by a superimposition of circular motions.

Respectfully submitted

[Little figure of an Elephant]