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Opening Address at Gauss Bicentennial Symposium

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by

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I consider it a great privilege to be asked to introduce this Symposium. We are celebrating to-day the 200th anniversary of the birth of Carl Friedrich Gauss. For many scientists the name of Gauss is one that they use almost every day. The method of least squares was invented by Gauss at the early age of 18 and it is as valid to-day as when it was first proposed; it is certainly used very widely in all the physical sciences. The basis of the least squares method is the Gaussian distribution of errors which every experimentalist has to contend with in one way or another. Gauss himself used the method of least squares in his extensive practical work on geodesy, another of the many fields to which he made the most basic contributions.

Gauss's extensive and basic work on magnetism induced later generations to call the unit of magnetic field intensity the gauss. Some purists following rigidly the new S.I. system have tried to get rid of the unit gauss, yet it has persisted in most papers on basic physics.

As a mathematician Gauss ranks with the greatest of the past 2000 years and I am sure we shall hear more about that later in this symposium. In theoretical physics the very concept of potential, so important in all of physics, was first formulated by Gauss. The whole field of geomagnetism owes its existence to the fundamental work of Gauss and Weber. The development by Gauss of differential geometry and of the beginnings of non-Euclidian geometry were basic to the development of relativity theory by Einstein. Thus it seems more than appropriate that physicists also should celebrate the bicentenary of Gauss's birth.

Gauss spent most of his adult life at the University of Göttingen, from 1807 until his death in 1855. It is he who made the University of Göttingen famous; indeed it became one of the most distinguished universities in the world. With a succession of world-renowned mathematicians following Gauss, such as Dirichlet, Riemann, Klein, Minkowski, Hilbert, Courant and Weyl, it was generally considered the mathematical capital of the world until 1933, when Hitler destroyed this prominence. On the basis of its strong mathematical foundation the University of Göttingen also became one of the most important centres, if not <u>the</u> most important centre, in physics and chemistry. The birth of quantum mechanics took place here when the young Heisenberg developed it and Born and Jordan recognized its mathematical structure. Heisenberg's uncertainty relation as well as the statistical interpretation of quantum mechanics by Born represent in some way a development of Gauss's original idea about the distribution of errors in measurements. However, in the atomic and sub-atomic world the Gaussian distribution is a necessity; its width cannot be made smaller and smaller by improving the accuracy of the measurements. There is a definite boundary to our knowledge of any physical system, namely such that the product of the uncertainty of position and momentum cannot be smaller than Planck's constant h. Heisenberg in many ways may be considered a worthy successor of Gauss. Like Gauss before him in the 19th century, Heisenberg changed the course of science in the 20th century.

It was my privilege as a young postdoctorate fellow to spend one year in Göttingen shortly after Heisenberg's discovery and to inhale the atmosphere of excellence that pervaded Göttingen University. Heisenberg had by then left Göttingen but returned for visits on several occasions. Born was writing his masterly book on optics. James Franck pursued his studies of atomic and molecular processes (he had just discovered the Franck-Condon principle). Hilbert was still alive but I never saw him. Many other younger people, later very distinguished, were there. It was a time of incredible scientific and mental stimulus.

In his inaugural lecture at the University of Göttingen in the fall of 1808 Gauss said:

> "The (fortunate) great minds who created and extended astronomy and other beautiful parts of mathematics, were certainly not motivated by the prospect of future usefulness: they were searching for knowledge (truth) for its own sake and found reward and happiness in the success of their efforts."

This is a thought that many scientists before and after Gauss have expressed and yet it is a thought that distressingly few non-scientists appreciate. Ever so often we hear the opinion expressed that the only purpose of science is economic and social advance, that is, lies in its applications. When I visited India a year ago I read in one of the local newspapers a statement like this made by Mrs. Gandhi whose father certainly knew better and did have a full appreciation of science as a field of knowledge. It still remains that the motivation of many scientists in their work is not economic betterment but is the striving for knowledge for its own sake. Nevertheless, as a consequence of Gauss's work in pure mathematics and pure physics many applications resulted which could not have been done without his work. He himself invented the telegraph in connection with his work on magnetism, and there are of course many other applications of his work on geomagnetism. This of course is only a small facet of the immense contributions that resulted from Gauss's work in the development of modern technology. But these applications were not foreseen by Gauss and could therefore not have been a motivation of his work. That motivation consisted of the thoughts he expressed so well in his inaugural lecture (which I quoted): it was the search for knowledge and truth.

Gauss rose from very humble beginnings to become the leading scientist in the world of his time in spite of the fact that he lived in a society which did not really favour those of humble birth. It was, however, a society that appreciated intellectual accomplishments and it is a credit to that society that Gauss's intellectual stature was recognized so early in his life. One may wonder whether Gauss would have had as good a chance in our egalitarian society. Nowadays people who talk about the need to preserve and encourage excellence tend to be considered elitists, as if that were something bad. Even if we were only interested in economic betterment we would still need excellence of individuals to produce the discoveries that will help to solve our problems like over-population, pollution, energy, and all the rest. In our educational system we must find ways to recognize and to encourage excellence, and if we are wise we must not try to circumscribe what scientists and other intellectuals are doing even if it is not obviously connected with our survival.

In celebrating the bicentenary of the birth of Carl Friedrich Gauss we have the opportunity to reflect how great a contribution he has made toward the development of our understanding of the universe around us and how rare it is that geniuses like Gauss appear in our midst.

It is a sobering thought to realize how much of our cultural development is due to a very few men of genius. We must thank the organizers of this Symposium for the opportunity to honour the memory of Carl Friedrich Gauss. The lectures that we are about to hear will make it clear to us how great is the debt we owe to Carl Friedrich Gauss for his contributions to knowledge.