WELCOME ADDRESS
OPENING CEREMONY, JANUARY 31, 1983
SYMPOSIUM ON PRECISION MEASUREMENT AND GRAVITY EXPERIMENT

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Mr. Chairman, Distinguished Guests, Ladies and Gentlemen:

As we all know, our ability to measure plays an essential role in the course of civilization. It is clear that the advance of human society demands better ability to measure and more precise common standards. On the other hand, the achievements of metrology——the science of measurement——provide a needed foundation for society's advancements.

With the advent of lasers, metrology and precision measurement entered a new era. As will be reported by Professor J.E. Faller, the ranging with lasers to the moon to measure the 384,000 kilometers distance between the moon and the earth with a precision of 15 centimeters dramatizes these developments. The use of laser interferometry in the free-fall absolute measurement of the acceleration of gravity is another example.

Measurements of g, the gravitational acceleration, have always made maximum use of the available technology in measurement of length and time. With an accuracy of a few parts in 10^{+9}, gravimeters presently represent excellent tools for global, local and temporal studies of the earth's gravity, and also for use in prospecting for minerals and oil deposits.

Today, precision laser spectroscopy challenges experimental and theoretical physicists both to make more precision measurements and to find adequate theoretical models——and new physics. Picosecond and femtosecond laser pulses make the study of ultrafast biological, chemical and physical phenomena possible.

In 1915, Albert Einstein proposed a beautiful and profound gravitation theory called General Relativity. Sixty-eight years later, general relativity still provides great challenges to the experimentalists. Searches for gravitational waves——the dynamic predictions of general relativity——arouse wide public interests and provide opportunities for many technological improvements. The Stanford gyroscope experiment, which will be reported by Professor C.W.F. Everitt, is another good example. According to general relativity, near a massive rotating body like earth, the local inertial frames around will be dragged along. With 19 years of efforts, the Stanford gyroscope experiment has now reached the point where it is ready to undergo the next stage——an actual flight in orbit to detect this effect. Most important, the attendant technologies——Gyro Technology, Ultra-low Magnetic field, Dewar Develop-

ment, Drag-Free Control and so on——have been driven to new levels of sensitivity and precision. These have already found many applications in technology and science. In the area of gravitational physics, we find that the advancements of fundamental tests and technological developments go hand-in-hand.

Different areas of precision measurement and gravity experiment have close ties among them. The advancement of one area may revolutionize some other area. They also have close ties with fundamental physics. The development of precision measurement techniques makes tests of fundamental theories possible; the discovery of new physical phenomena and their attendant applications may lead to a revolution in precision measurement.

Today, more than one hundred scholars, experts, junior workers and students from Japan, Hong Kong, the United States as well as the Republic of China gather together to attend this "International Symposium on Precision Measurement and Gravity Experiment". We have many distinguished speakers from many areas of these fields. We have good reasons to expect that this symposium will produce a good harvest of international academic communication and cooperation. This is important to us especially at a time when the ROC is pursuing an in-depth development of fundamental sciences and when our laboratories of metrology and national standards are in the initial phases of being established. On behalf of the conference sponsors——Academia Sinica, Ministry of Education, National Science Council, National Bureau of Standards, Industrial Technology Research Institute, Telecommunication Laboratories, National Central University and National Tsing Hua University, I am here to extend to all of you, Guests and Participants of distinction, foreign and domestic, our hearty welcome. I gladly avail myself of this opportunity to wish each one of you a great success and a happy Chinese New Year. Thank you.

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Mr. Chairman, Dr. Chien, Distinguished Guests, Ladies and Gentlemen:

It is a very nice "experiment" to be invited to speak at this symposium. In the International School on Precision Measurement and Gravity Experiment last week, we learned some basic advances and precisions. Now we come to the symposium, we look for better precisions. On behalf of the Industrial Technology Research Institute——a symposium co-sponsor, I wish everyone of you to have a very successful meeting.

With the advances in industrial technology, precision measurement is not limited to scientific and academic laboratories but also becomes a necessity for industrial day to day operations.

In the process of upgrading industries of the Republic of China from labor intensive to technology intensive bases, one of the major efforts of Industrial Technology Research Institute is to promote industrial applications in metrology and to establish calibration standards in cooperation with the National Bureau of Standards, MOEA. Our plan calls for the joint efforts of universities and research institutes as well as international cooperations with institutions abroad.

Our task is twofold: At one end, we have to look into the scientific bases in metrology to lay the foundation for fundamental measuring units and developing precision methods to maintain and transfer throughout the calibration echelons; on the other end, we have to transplant the methodology generally found only in scientific laboratories to the industrial environment.

This symposium is very timely in keeping us exposed to the recent advances in metrology and calling the attention to the scientists and engineers of this country to this somewhat neglected but very important field.

As we all have heard from Dr. Chien's address, different areas of metrology, precision measurement and gravity experiment have close ties among them. The skills, methods and ingenuities developed from the field of gravity experiment give impetus to the advancement of metrology and precision measurement. Therefore, we shall undoubtly benefit from the coming discussions on gravity experiment also.

We are particularly grateful to the distinguished guests from United States, Japan and other countries for their time and efforts to participate. As authorities in their respective fields, their lectures will be a milestone in our science and technology development. I wish also to express our respect to the local experts. Their efforts have formed the very basis of ROC scientific development. Finally, I wish that the meeting is successful, and am looking forward to the fruits of this symposium. Thank you.

INTRODUCTORY REMARKS
OPENING CEREMONY, JANUARY 31, 1983
SYMPOSIUM ON PRECISION MEASUREMENT AND GRAVITY EXPERIMENT

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Dr. Chien, Dr. Fang, distinguished guests, and friendly students -- I thought I would give you a few thoughts on the subject of precision measurement. I was told that I was to give this talk only after I arrived here in Taiwan, so as all American physicists are known to do, I have prepared my talk on the back of an envelope (large written-on manila envelope produced). I will first talk about a question that used to bother me, and the question is, should it be precision measurement or precision measurements -- with or without the s? The answer is precision measurement because were it precision measurements you would be given the idea that there is an experiment of this type over here, another experiment over there, and another one somewhere else -- and somehow they aren't related. On the other hand, if it is precision measurement, then it implies that one can think of it as a scientific field or discipline where what one learns in one experiment can be and should be applied to other experiments. It becomes a way of thinking. So it really should be precision measurement and not a group of miscellaneous and unrelated experiments that we do. That's my first thought. Now let me talk briefly about some of the ideas that are involved.

The fundamental task in precision measurement is to raise the level and accuracy of new and old measurement procedures, and in order to do that we need to increase our understanding both of the physical laws involved and of the material processes that underlie and dictate the quality of measurement. As measurement requirements become more and more demanding it requires sophistication both in advancing present-day technology and applying it to these problems. This creates a continuous challenge to our skills and to our creativity, and that makes it fun. As to interactions, the field of precision measurement draws enormously on acquired experience and must utilize the knowledge and experience of others who are working in the field. And that's why we have meetings like this!

The same thing said in a slightly different way (at least as I see it) is that we try to use new concepts, new techniques, and new insights to deal with fundamentally related high-precision and applied measurement problems which are encountered in the broad range of science and technology.

A major difficulty encountered in this field involves something called systematic errors -- the types of errors which may contribute somewhat to the scatter in the data but which chiefly shift the measured value from the "right" one. Let me give you a brief statement of the

problem that I once wrote. "Because we are aware of earlier results (or predictions) we tend to look for and find systematic errors which permit us to correct our result until it stands at least close in the shadow of these measurements -- at this point we stop looking (because we have now got the "right" answer), we fold up our equipment, and publish our 'new' results in substantial agreement with..." Now that's the problem. You might say that grown men, especially physicists, would never fall prey to such things. Let me give you one example to think about. It comes from the 1961 paper by Mandelberg and Witten (JOSA, Vol. 52, No. 5, May, 1962, pp. 529-536). They re-did the Ives-Stilwell experiment which was published in 1938 (an experiment which was also performed by Otting in 1939) involving a measurement of the second-order Doppler shift. I would call your attention to the beginning of the paper -- where Mandelberg and Witten are justifying why they are re-doing this experiment. They state, "An analysis of the experiments of Ives and Stilwell indicate that although their reported experimental points seem to fit the curve with an accuracy of about 2-3%, the experimental uncertainty is more nearly 10-15%." The above quotation is from the first page of their paper; now let me read you what they say on the final page of their paper. "In the region described approximately by $0.0045 < \beta < 0.0065$, lie eight consecutive points we have measured, each of which lies below the theoretical line. However, in this region most of the points measured by Ives and Stilwell lie above the line; taking the experiments together gives a reasonable spread of measured points about the theoretical line in this velocity range." I hope the students in this room will read this JOSA paper and think very carefully about those two pages.

I'd like to close with what I think are the chief requirements for working in the field of precision measurement (as a part of which I include fundamental constants and null experiments). When I read Nicholas Nickleby some years ago, I was struck by the truth of one of Dickens' sayings (Chapter XLIII): "Pride is one of the seven deadly sins; but it cannot be the pride of a mother in her children, for that is a compound of two cardinal virtues -- faith and hope." This quotation points to the three most important qualifications needed to work in this field: you need to have a great deal of pride in what you are doing, and you also have to have a great deal of faith and hope. Thank you very much for your kind attention.