Nombrado Doctor Honoris Causa en el acto del día de la Universidad del curso 98/99

Rector Magnifico, Sr Peces-Barba Martínez and members of the faculty of the University Carlos III of Madrid: May I thank you most deeply for this very high honor and privilege that you have conferred on me. It will be one of the proudest moments of my life. May I also specially acknowledge Professor Figueiras-Vidal, not only for his gracious remarks a few moments ago, but also for his efforts to bring about this honor for me, and for many years of friendship and interaction.

On the other hand, about the gracious remarks I just mentioned, I must confess that I understood very little of what he said! However, I must add quickly that my wife, Sarah, has been studying Spanish and soon she will be able to read out his kind remarks to me! Before I proceed, I would also like to thank some good friends who made a special effort to be present on this happy occasion: Professor and Mrs. Mohamed Najim of Bordeaux and Professor and Mrs. Emanuel Protonatorios of Athens.

Of course, I know well that honorary degrees are not only about pleasure. To them applies well what Portia said in the Merchant of Venice about the quality of mercy, that "it is twice blest, it blesses both those who give and receive." So also from now on, I shall have an even more special feeling for and a special responsibility towards the UCM and especially its department of Systems and Telecommunications. Fortunately, this is not going to be difficult. I believe that Telecommunications is, at the present time, one of the most important fields of technology. And I was happy to see, even in the short time that I was here this week, that the scope of the work in Professor Figueiras-Vidal's telecommunications research group is even greater than I had been aware of earlier. For example, some of his groups are exploring applications of the latest results in the apparently very different area of "mathematical learning theory" to problems in communications. This is a novel direction and I expect to see important results arising from this work. Now, a few remarks about telecommunications and the challenge for universities. We may be so used to certain features of modem telecommunications that we often forget two things: how comparatively recent many of these features are and how rapidly they are evolving (we speak these days of INTERNET time). Some examples: It was

1. less than 25 years ago, that direct dialing of international calls became possible everywhere.
2. less than 15 years ago, that fax machines first became reasonably cheap
3. less than 10 years ago, that cell phones began to be widely used
4. less than 5 years ago, that e-mail, the WWW and the Internet really carne on the public scene.

These and many other wonders of the Information Age have two main foundations. The better known one is the amazing development in electronics. You may have heard of what is called Moore's Law that every 18 months or so, the capabilities of an IC (Integrated circuit) chip double while the cost halves. The consequences are many. An example familiar to al¡ of us is that when fax machines first appeared as a consumer product, they were very expensive and quite cumbersome-remember the special rolls of thermal paper which faded away after a while. Five years ago, 1 wanted to buy a plain paper fax machine, but it cost $2000, so for $700 I bought the old fashioned type with thermal paper. Now in Palo Alto, I can buy a plain paper fax for less than $100! Another dramatic example: the price of computers is dropping rapidly. Easily below $1000 in the US and very reasonable ones for less than $500. So more and more people are buying PCs for their children and to get on the Internet. And this brings up an interesting economic fact. If you calculate that a PC lasts about four years, the cost of ownership for a $1000 PC costs $20 pm to own. The present monthly fee for Internet access (US prices) is about $20 per month. But the price of computers is falling much more rapidly than the cost of telecommunications. So in a few years, PCs should get so cheap that Internet Companies will give away versions of them for free! It's not so far fetched. Cell phones are free or almost free if you subscribe for 1 or 2 years! The point I want to make is that soon computation will be free, or almost so, and communications will be the driver of progress.

Another lesser known foundation for this revolution, even in academic and industrial circles, is what is beginning to be called Mathematical Engineering (compare with Mathematical Physics). Briefly, this first involves abstracting and simplifying a real word problem so that one can make a mathematical model for the problem, be it in automatic tracking and control, Very Large Scale Integration (VLSI) design, feature detection in images, high-speed digital

communications in various environments, diverse problems in semiconductor manufacturing, and many others. Secondly, one uses, and sometimes develops ab initio, a variety of often surprisingly advanced mathematical tools to solve the idealized problem. The final step is to gain a sufficiently physical and intuitive understanding of the mathematical solution that one can translate it into a "practical" solution of the original physical problem. The word practical of course has many aspects, from technical feasibility to economic viability.

This methodology is not uncommon in physics, but it really began to gain currency in engineering only during World War II, with Norbert Wiener and Claude Shannon being the intellectual leaders. The distinction from physics is that there is a greater use of what engineers call a systems point of view, with many of the mathematical techniques having been developed by engineers in the last 50 years. The specific technical origins were in the field of Information Theory, founded by Shannon in 1948. This subject was long regarded as hopelessly abstract and complicated, but many of the miracles of the Internet era now rely heavily on the digital representation of information that was the first step in Information Theory; in addition of course are many remarkable, and heavily mathematical, specific results in compression, coding and encryption that are known in fields such as control theory and signal processing. I may note that in the early days, such mathematical research in engineering was regarded as so far removed from commercial potential that it was only the large defense budgets of the Cold War era, and the evident contributions of scientists during WW II, that allowed the funding, mostly in research universities, of such work. Moreover, even now the idea often meets resistance. But I believe that this is in fact an advantage for the practitioners of mathematical engineering, because it makes competition harder for those companies that build on such methods, as opposed to the "cut-and-try" approaches often favored by many "real" engineering companies.

I hope you will forgive me here for mentioning that in the technical seminar I gave yesterday, an example of just such a phenomenon was described, where starting from our research, a theory-based company was spun off that is dramatically accelerating the progress of Moore's law. This is not the place to give technical details, but in keeping with the times, I can mention the website for those of you interested in more details, www.numeritech.com.

One reason for mentioning all this is that Professor Figueiras-Vidal has been a leader in Spain in propagating Mathematical Engineering, and the group he has developed in the last few years is already visible on the international scene. I am indeed happy that the award of this honorary degree gives me even more reason to have increased interaction with them and, in fact, with other groups at this University. It was a pleasure to meet here again. Professor Marcellan, of the Mathematics Department - we have some common interests in the subject of orthogonal polynomials. So, once again, thank you al¡ again for this high honor that you have conferred on me today.