## Opening and Parting Remarks

Let me start by welcoming all of you to this small meeting, particularly those who came from far away to contribute to this meeting.

This is the second in series on the topic of skyrmions I helped organize in KIAS. While on the KIAS faculty, I began the series in January last year for which Byung-Yoon Park, the leading expert in this field in this country, played an invaluable role. The main theme of last year's meeting was the interdisciplinary character of the meeting covering condensed matter, particle and nuclear/hadron physics with a focus on the common theme of topological solitons in physics.

Since then I left the faculty of KIAS. But thanks to the efficient help of Tae-Sun Park, the principal organizer of this meeting and to KIAS' support, we can have this second. Regrettably, this may be the last such meeting on the topic in this institute, so this opening speech will be the parting one as well. I hope however that it will continue with the third and fourth and so on elsewhere in this country if not here.

This meeting is funded by both KIAS and Hanyang University. In this connection, I would particularly like to acknowledge the generous and innovative support of President Chong Yang Kim of Hanyang University without which this meeting could not have been organized in the present scope.

A colleague of mine in RHIC physics visiting me just before last year's workshop jokingly asked me: "What's the big deal with the skyrmion? Isn't it an old stuff?" As an answer I just mumbled about the current work I had been doing with my Korean collaborators on dense hadronic matter in terms of skyrmions with huge topological quantum numbers. Well, you will hear more on this from Vicente Vento in this meeting. But the main reason why I wanted to have the meeting last year was that Gerry Brown of Stony Brook and I had been invited to edit a volume on the current impact of Skyrme's work in physics in general, say, a sequel to the volume edited by Gerry Brown sometime ago.

Now, in contrast to last year, I can answer that question both un-hesitantly and enthusiastically. The reason is, as I will mention later, that "several exciting things happened in the meantime and we are going to address some of those exciting developments this time."

To give you an idea what I am driving at, let me go 17 years back to 1987. That's the time many prominent theorists working on skyrmions were

abandoning the problem to rush to string theory which underwent the first string revolution. In May, 1987, a workshop with the title "Skyrmions and Anomalies" was organized near Krakow, Poland. by Marek Jezabek and Michal Prasalowicz – who I am happy to say is here. I was invited to that workshop and asked to summarize the meeting.

There are two amusing anecdotes connected with this meeting I would like to tell you about, one personal and the other scientific. Let me start with the first one which you might find quite amusing. In 1987, the diplomatic relation between Poland which had just stepped out of a communist regime and South Korea where communism was - and still is - outlawed was not yet well established. That is, Daewoo commercials did not yet appear on the streets in Poland. Having a Korean nationality then which I still have after so many years in France, I was not sure to get the visa to enter Poland. The Polish hosts went ahead anyway and made special applications for my visa. To the surprise of both the hosts and myself, however, the Polish consulate in Paris gave me the visa with no fuss whatsoever, so I could indeed go to the meeting. This was quite a surprise to me because in the previous year, my application to go to Beijing was rejected outright. I wasn't feeling very comfortable entering the country but there was no difficulty in both getting in and getting out. A few weeks after my return back in France, however, I was informed by my Polish hosts that my visa application was formally rejected. What happened was as follows. The application had to be made to both the foreign ministry and education ministry of Poland. The foreign ministry approved and so the visa was given, but the education ministry rejected the application (I am not so clear whether it was not the other way around), so the visa application was officially rejected and hence officially I did not enter the country although I did go in and gave the talk.

After all this happening, a Polish colleague of mine concluded that it was a political case of the Cheshire Cat phenomenon. You will see later what he meant by this. I put this remark in the written version of my summary talk of the 1987 meeting.

This brings me to the physics anecdote. As mentioned, I summarized that meeting. There were two broad sub-fields discussed there, one mathematical and the other physical. Let me come back to what I said about this interplay of two sub-fields and the total absence of experimentalists there. Let me first make a big confession here; I am terribly ashamed of the colossal omission I made in my summary of the 1987 meeting and the omission was Michal Praszalowicz's seminal prediction for the pentaquark. Well, Michal, please

accept my apology for having failed to recognize the importance of what you were saying at that time!!

Incidentally Diakonov who has since played an important role with the pentaquark development, particularly from the experimental side, was also attending that meeting. I don't know whether he paid attention to Michal's talk at that time.

Thinking about it now, I see why I plum missed Michal's prediction. I liked the notion of skyrmions very much then but I did not see the connection to QCD with explicit quarks and gluons; I was a bit skeptical about its predictive power. So Gerry and I were building a picture where we started with a big bag of confined quarks and gluons, squeezed the bag with the pressure due to the Goldstone boson cloud generated by spontaneously broken chiral symmetry and made the bag as small as we wished so that we could do nuclear physics. The baryon charge leaked out of the confinement area. Skyrme's work hinted at the mechanism to do this - and we with Vicente Vento who was a student early in 1980's at Stony Brook saw it – but in fact it is Anti Niemi who is here with us and who was also at the Krakow meeting who taught us how to fractionize the fermion charge using solitons into inside and outside of the bag. Holger Bech Nielsen subsequently dubbed this notion – that the confinement size can be arbitrarily changed without changing physics – as "Cheshire Cat Phenomenon." What is happening is now understood as follows. There is an anomaly on the confinement boundary that allows the leakage of baryon charge into the pionic cloud, while the total baryon charge is conserved. Gerry and I liked this idea very much - and we still maintain stubbornly this to be how nature works – since it gave us a way of convincing ourselves that there would be no abrupt changes between the confined and deconfined phases.

I was so obsessed with this idea at that meeting that I paid little attention to predictions made with pure skyrmions, including Michal's!!

You see, my entry in and exit from Poland must have been a Cheshire Cat Phenomenon: There must have been an anomaly there at the Polish boundary.

My starting theme of the summary talk at the Krakow meeting was the two laws of physicists put forward by T.D. Lee. Let me make them the ending theme of my opening remarks here. T.D Lee's two "laws of physicists" are:

1. First law of physicists: Without experimentalists, theorists tend to drift.

2. Second law of physicists: Without theorists, experimentalists tend to falter.

I believe these laws are still quite applicable today and I am going to hang onto them.

I started out by saying that there are some stunning developments in experiments which make this meeting quite timely and appropriate and that these should bring the theorists back on the right track.

In addition to the controversial pentaquark discovery which was the theme of a several workshops in Korea including the one of last Spring held at Hanyang and which will be further discussed here, there are two stunning observations.

One is the amazing discovery by Toshi Yamazaki and his co-workers in Japan of a dense nucleus with three nucleons bound by negatively charged kaon. Toshi succeeded by a very clever technique in embedding a kaon inside nuclear interior. In fact, last November, Toshi reported his preliminary result at KIAS' astro-hadron meeting. The strong attraction associated with chiral symmetry breaking makes the system highly compressed by strong interactions. The interior density of this imploding system comes to about 10 times normal nuclear density, simulating the condition believed to be met in the interior of the densest stable star in the Universe. It is plausible that this can be studied with B=3 skyrmions. In conjunction with the GSI machine that will go into operation around 2007 to create extreme conditions for hadronic matter, there is in store a real surprise in this field, a possible breakthrough potential.

Another development I would like to bring to your attention is the result of the recent RHIC experiments in which the matter above the critical temperature at which symmetry change from Goldstone to Wigner mode takes place is interpreted to be an almost perfect colorless liquid, a totally new state of matter, not at all like a plasma of deconfined quarks and gluons as naively predicted. This smells like the smooth change Gerry and I have been talking about in terms of Bèg-Shei theorem and the Cheshire Cat phenomenon. In this direction, the forthcoming ALICE detector at LHC/CERN will generate activities starting from 2007, making its endeavor the center of hadron and particle physics for the decades to come.

So what does this all amount to? Numerous people outside of the field have asked me the question "what does the skyrmion have to do with QCD?" By way of answering this question, let me quote Weinberg once more as I did

in 1987: "an analogy may be useful between QCD and another science that I think it will increasingly come to resemble, hydrodynamics. In both cases we think we know the underlying equation: the Navier-Stokes equations in hydrodynamics and YM equation for QCD. In both cases fascinating, important hard problems have not been solved. In hydrodynamics, there are problems involving flow at high Reynolds numbers - phenomena such as turbulence and chaos. In QCD there is everything having to do with low energies and long distances: glueballs, confinement, phase changes. Turbulence is a fascinating subject and will go on interesting physicists for many years but we do not study turbulence to test (or make connections to) the Navier-Stokes equations. In the same way I think that all the really interesting problems of QCD have nothing to do with testing (or making connections to) QCD. ." I agree with this assessment. Let me also add my own personal conviction: Skyrmion is a universal concept not restricted to a particular fundamental theory or even to a particular field of physics. I believe that various different fields can teach each other in exploiting the true nature and power of skyrmions.