Introduction

Zhou Guang-Zhao's scientific career is divided into several periods:

I. Early period (around 1955-1956). He was working in China.
II. DUBNA period (1957-1960). Zhou was prolific in this period, publishing many papers in the JETP. I was in the USA at the time and had studied several of his papers, especially his work on PCAC. In the USA he was famous as the most brilliant young theorist in Dubna.
III. National defence period (1961-1979). Zhou returned to China and ceased publication in scientific journals. But I had seen in a museum display in Qin-Hai Province the cover page of the design report of the first Chinese atomic bomb. It bears the names of Zhou and Deng Jia-Xian. Rumors say Zhou had made crucial contributions to that design, using analytic methods without the use of computers.
IV. Later period (1979-around 1987). Zhou was at CERN, later at the VPI in the USA for several years, then back to China. In this period Zhou resumed his interest in academic research and was active in several frontier area of theoretical physics, often with young collaborators.
V. Recent period (1987-). Zhou is busy with Academy of Science matters after the late 1980s. But he still keeps up his interest in physics research.

I had first met Zhou at a dinner in Beijing hosted by Premier Zhou En-Lai in the early 1970s, almost forty years ago. During these forty years we have become close friends. I am deeply impressed by how he had transformed himself in the 1980s from a research physicist into an influential and highly respected policy maker and administrator. His success is partly rooted in his genes, of course, but I believe, also very much in his principled Chinese cultural background.

Zhou is a first rate physicist: broad, powerful and very quick in grasping new ideas. His style of doing physics reminds me of that of Landau, Salam, and of Teller. But in personal relationship Zhou is a perfect Confucian gentleman, without

the aggressive edges that characterize so many famous US, European and Russian theoretical physicists.

C. N. Yang

Introduction

Professor Kuang-Chao Chou (Guang-Zhao Zhou) was born in Changsha, Hunan Province in 1929. Upon graduated from the Department of Physics at Tsinghua University in 1951, he enrolled as a postgraduate student in theoretical physics at Peking University where he became as a faculty member in 1954. He then immediately carried out several research works on nuclear physics and particle physics published in Chinese journals [1c,2c,3c].

In the period 1957-1960, Prof. Kuang-chao Chou worked as a researcher at the Joint Institute for Nuclear Research (JINR), Dubna in the Soviet Union, where he published more than 30 papers and made significant contributions in several important subjects concerning symmetries. His first paper at JINR was the issue on a symmetry property of the new Gell-Mann theory [1]. He then paid special attention to the spins and parities of particles [2,3,6], which enabled him to establish the relativistic theory of reactions for the polarized particles [7,8] and especially for the massless polarized particles [13], where he introduced, for the first time, the concept of helicity amplitude and its corresponding mathematical description, which has been shown to be very powerful in analyzing high energy scattering amplitude. He studied at the first time the particle-antiparticle asymmetry (CP violation) in the hyperon decays [10,14,23], where he proved an important theorem in CP violation, i.e., when CPT is invariant but T reflection is not conserved, the decay branching ratios of particle and anti-particle to different states may be different although total decay widths are the same. He also noticed in the early time the possible symmetry properties for the π-K system [22]. Its group symmetry was realized late on as the SU(3) symmetry by Gell-Mann in 1961. The renowned important paper written by Kuang-Chao Chou was on the pseudovector current and lepton decays of baryons and mesons [26], which has been an initial paper for proving the theorem of partial conservation of axial current (PCAC) in a simple and concise way, and it has been reputed to be an outstanding contribution in the research of hadron physics. He also conducted some interesting works concerning charge symmetry properties [11,18], and a series research works on dispersion relation, photo-nuclear reaction and scattering processes of mesons and hyperons [16,20,23–25,27,28,30–34,9c,10c,11c]. He

also calculated at the first time the mass difference between neutron and proton [4c]. With collaborators, he also studied the capture of muon in nucleus [5c,6c,7c,8c]. It was a very productive period for Prof. Kuang-chao Chao, his works immediately attracted special attentions worldwide, for instance, his most significant and fundamental work on PCAC [26] motivated the renowned paper on "Dynamical model of elementary particles based on analogy with superconductivity" by Y. Nambu and G. Jona-Lasinio (Phys. Rev. Vol. 122, No.1 and Vol. 124, No. 1, 1961), for which Y. Nambu won the Nobel prize in 2008. Due to those remarkable achievements, Prof. Kuang-chao Chou was highly praised by the international scientific community and became a world-renowned theoretical physicist.

The period 1960's was a golden time for particle physics. It was also the most creative period for Prof. Kuang-chao Chou carrying out the important initial works in the frontiers of particle physics. Nevertheless, it was in this important time, Prof. Kuang-chao Chou made an alternative and unusual choice that he decided to give up his research interest and the advanced working and living conditions at JINR when he learnt that the project of atomic Bomb in China met some hard problems in its first stage of design and all the relevant experts from Soviet Union had to leave China. In 1961, Prof. Kuang-chao Chou returned back to China and took part in the theoretical study and design of the atomic Bomb, which was known to be the most mysterious project. He then analyzed carefully all formalisms used in the computations and checked in detail all the numerical calculations. Eventually, he solved the hard problems caused in the design of atomic Bomb and made a decisive and right judgment based on the first physical principle. It was this breakthrough, made by Prof. Kuang-chao Chou, which played a crucial rule for the success of the first atomic Bomb (1964) in China. During the period 1961-1978, Prof. Kuang-chao Chou made important contributions in the development of atomic energy, applied physics and computational mathematics, which included the high temperature and high density physics, explosion mechanics, mechanics of radiative fluid, neutron physics, plasma physics and computational mechanics.

In 1978, Institute of Theoretical Physics (ITP) was approved by the vice Premier Deng Xiao-ping to be established at the Chinese Academy of Sciences (CAS), Prof. Kuang-chao Chou joined the Institute of Theoretical Physics. In the period 1979-1987, he was able to work again on the frontiers of theoretical physics. In the early 1980s, he worked as a guest researcher and professor in the Virginia Polytechnic Institute, USA and the European Organization for Nuclear Research.

Prof. Kuang-chao Chou made a number of important contributions in multitude research areas of theoretical physics. In the field of high energy particle physics, under his leadership, some significant achievements have been yielded at several interesting subjects, which included the gauge field theories [35–41,43,45,49,52,12c,13c,14c,15c], nonlinear sigma models in symmetric coset and

curved spaces [46,47,50,51,56,64,68], U(1) anomaly and chiral dynamical theories [42,44,48,53,57,73]. The most important observations by Prof. Kuang-chao Chou and his collaborators were the gauge invariance and anomaly-free condition [58,16c,17c] of the Wess-Zumino-Witten effective action and the topological origin of gauge anomalies [60]. In the paper [59], it was firstly pointed out that Wittens effective Lagrangian for chiral field missed some important terms. Thus the topological properties of gauge fields were extensively explored in several papers [62,63,67,18c]. Late on, a simplified derivation of Chern-Simons cochain was realized [71] and it has been adopted to obtain the general Chern-Simons characteristic classes [72,19c,20c]. In particular, several interesting physical applications have been investigated, which included the derivation of the anomalous term in Virasoro algebra [69], the effective action of sigma model anomalous with external gauge fields [70], the possible origin of θ-vacuum etc. At the same time, Prof. Kuang-chao Chou also paid special attention to the phenomenology of weak interactions. In particular, an interesting observation was made on the correlation between the top quark mass and direct CP violation in kaon decays [65]. As a consequence, a heavy top quark with mass much larger than W-boson mass was predicted and emphasized, and a fourth generation quark was also motivated [66] at that time.

In addition to the gauge field theories and particle physics, Prof. Kuang-chao Chou (Guang-Zhao Zhou) has also made important contributions in the fields of statistical physics and condensed matter physics. With collaborators, the closed time path Green's functions has systematically been developed [79,80,21c,22c] and applied to the critical dynamics [81,23c,24c] and statistical physics [82,83,84,85,27c,28c]. A nice review article was published in Phys. Rep. 118, 1 (1985) which has widely been cited internationally. It has been shown that the method of closed time path Green's functions allows one to treat, in a unified way, both equilibrium and nonequilibrium systems. The method has also been applied to the random system [86,87,90] and the disorder electron system [88] as well as the Bohr-Sommerfield quantization for the fractional quantum Hall effect system [93]. The other interesting works conducted the spontaneous symmetry breaking [92] and time reversal invariance [95,25c,26c] in the nonequilibrium system as well as the influence functional [94].

In 1980s, Prof. Kuang-chao Chou has led, as the director of ITP-CAS, several key research directions at ITP, which concern: quantum field theory and particle physics, nuclear physics and plasma physics, statistical physics and condensed matter physics, gravity and astrophysics. For his outstanding contributions to theoretical physics, applied physics, atomic energy and basic research sciences in various aspects, and also for his great capability of leadership, in 1987, Prof. Kuang-chao Chou was pointed by the government to serve as the president of Chinese Academy of Sciences (CAS). Once again, he has to give up his own research interest and to

make alternative contributions for leading the development of sciences and technology at the CAS.

In 1996, Prof. Kuang-chao Chou was considering to return back to the scientific research. He presented in 1995 the opening address for the 17^{th} International Lepton-Photon Conference which was regarded as the most influenced International Conference on particle physics held in Beijing. After that conference, he was actually thinking about the most hot topics in particle physics, which involved CP violation, origin of mass, neutrino physics, supersymmetric theories, low energy phenomena of grand unification theories [74–77] and a general discussion on CP and CPT violating observable in meson decays[78]. It has been shown that the 18 unknown quantities in the standard model of particle physics can well be predicted by a minimal set of 5 parameters in a class of supersymmetric grand unification model [74], about ten relations among CP violating-phase, masses and mixing angles of quarks and leptons have been obtained, which remain consistent with the experimental data.

In 1997, Prof. Kuang-chao Chou would wish to realize his desire of doing theoretical research. Nevertheless, it was unexpected that he was elected to be the vice Chairman of Standing Committee of the National People's Congress of China and pointed again by the government to serve as the Chairman of the China Association for Sciences and Technology. Until 2006, he was honored as the honorary Chairman of the Chinese Association of Sciences and Technology. Since 2006, he has been invited to serve as the member of International Advisory Committee and the honorary Chairman of the Scientific Council for the Institute of Theoretical Physics at the Chinese Academy of Sciences.

In this volume, the most papers written by Prof. Kuang-chao Chou (Guang-Zhao Zhou) are printed. All the collected papers have been arranged into four parts according to the subjects of research areas and the languages of publishing journals. Part I (in English) and Part III (in Chinese) are the papers on Field Theories, Particle Physics and Nuclear Physics, Part II (in English) and Part IV (in Chinese) are the papers on Statistical Physics and Condensed Matter Physics. From the published papers, it is seen how Prof. Kuang-chao Chou caught up the frontiers of theoretical physics in various periods and carried out the creative research works with initial ideas and motivations, as well as how he has worked in different key research directions of theoretical physics and made significant contributions to various interesting research subjects and interdisciplinary areas.

Due to the outstanding research works and significant contributions, Prof. Kuang-chao Chou has earned numerous national and international awards which include: National Prize first order in Natural Science, Prize first order from Qiushi Foundation of HongKong, Gian Carlo Wick Commemorative gold medal from the World Federation of Scientists, the Chinese Meritorious Service Medals for Nuclear Scientists and Satellite Pioneers. He was elected in 1980 to be the Academician of

Chinese Academy of Sciences. He has also been elected as Foreign Associate of the US National Academy of Sciences, Fellow of the Third World Academy of Science, and Foreign Member of USSR Academy of Sciences, Czechoslovak Academy of Sciences, Bulgarian Academy of Sciences, Romania Academy of Sciences, Mongolian Academy of Sciences, the European Academy of Arts, Sciences and Humanities, Membre fondateur Academie Francophone d'Ingenieurs. He has been honored to be the honorary PhD of several universities which include the City College of New York in USA, McGill University in Canada, Chinese University of Hong Kong. He also served as the Executive Vice-President of China Commission for Promoting International Science and Technology, the vice Chairman and honorary Chairman of China Association for Peace and Disarmament. He was conferred Commendatore dellOrdine Al Merito Della Republica Italiana in 1993.

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