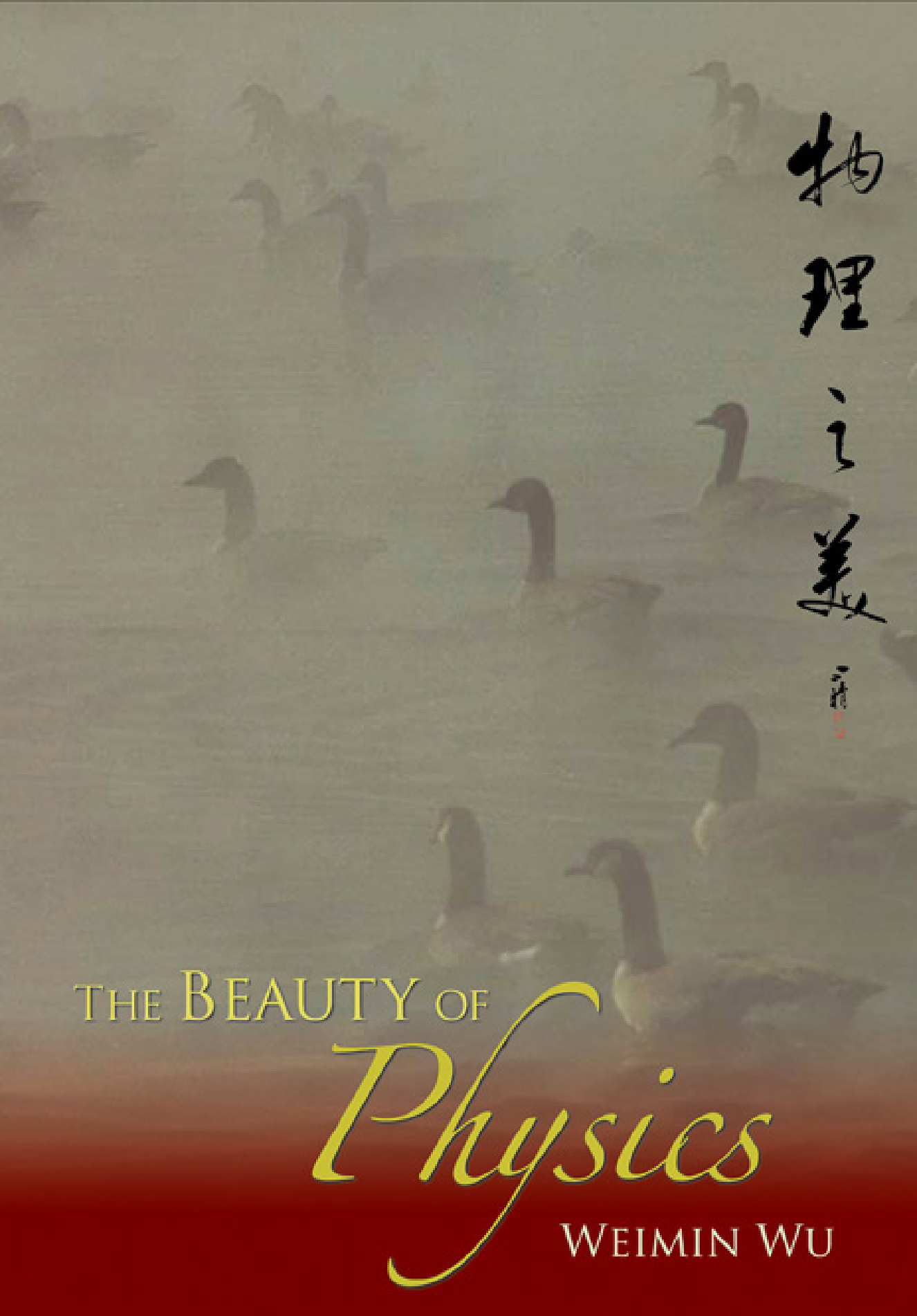
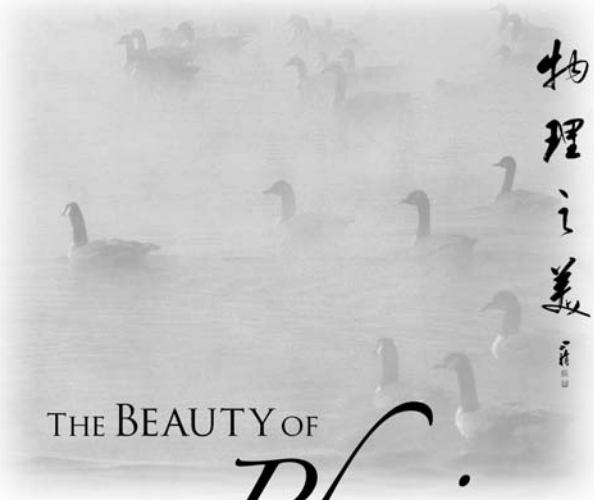


The Beauty of Physics

Weimin Wu



THE BEAUTY OF *Physics*

This page intentionally left blank

THE BEAUTY OF *Physics*

WEIMIN WU
Fermi National Accelerator Laboratory

World Scientific
NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

THE BEAUTY OF PHYSICS

Copyright © 2007 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN-13 978-981-270-560-0
ISBN-10 981-270-560-0

Printed in Singapore.

"I first met Weimin when he stopped me in the street to ask the way. He had just arrived in Geneva from Beijing to spend some time working at CERN and I remember thinking it was like meeting a man from Mars. Everything about the West was new and strange to him and he never stopped asking questions. What were credit cards and how did they work? Why was individualism considered a virtue in the West when in China it was equated with selfishness? As I got to know him better I realized this consuming curiosity was the mark of a true scientist. Another mark of a scientist is meticulous observation and this book illustrates the combination of these two characteristics. But curiosity and observation need something more to produce such photographs: an appreciation of beauty and the ability to seize a rare moment. In today's world of specializations, it is a joy to celebrate the work of a real Renaissance man."

— **Sally Alderson**, *British journalist*

"I met Weimin at CERN in the eighties — he must have been very young at the time — and I was impressed by his dedication and enthusiasm. Then again in 1986, at the IHEP in Beijing where he received us in his small apartment. After a few years he had crossed over to the west in his search for physics and a different life, as a true cosmopolitan in the tradition of the wandering scholars. This collection is about his search, for physics, for beauty, for beauty in physics, and also a voyage through memories. Weimin documents his personal search for beauty in nature, both where it is shouting for attention as in the flowers and birds, and where it is more subtly present as in the latticework of parched earth. He also documents the search for beauty by many physicists in the arrangement of their buildings and machines, towering with the sculpture and architecture by Bob Wilson at Fermilab. Beauty and memories are intertwined in his own relatives and in his great model figures, from Jack Steinberger to T. D. Lee and C. N. Yang, as well as his beloved teacher Ye Minghan. This is a book full of subtle messages, a beautiful book that must be taken in slowly and enjoyed again and again."

— **Nicola Cabibbo**, *former President of the Italian National Institute of Nuclear Physics, and President of the Pontifical Academy of Sciences*

"It is very nice to see this photo collection from Weimin. These wonderful photos show the beauty and harmony of nature and physics. Weimin is my old friend. The first time we met was during Summer 1985 at CERN. He worked for the ALEPH experiment at LEP, and I worked for the L3 experiment at LEP. We discussed about the computer link between the Institute of High Energy Physics (IHEP) in Beijing and CERN, which was our common interest for the international collaborations of particle physics. We worked together very hard to push the computer link between Beijing and CERN. An IHEP computer became the first Chinese node in the Internet. That was a great time."

— **Hesheng Chen**, *member of the Chinese Academy of Sciences, and Director of the Institute of High Energy Physics, Beijing*

"I vividly remember my first encounter with Weimin in Beijing in 1988 where I was kindly invited by Professor Minghan Ye. Weimin's enthusiasm and curiosity were striking, in physics of course, but also toward the world in general with an amazingly wide range of interest. I felt very close to him, especially during the Tiananmen events in 1989 where we kept in very close contact, daily sometimes hourly, thanks to electronic mail. Weimin's idea for such a beautiful book comes as no surprise to me, as he always had an eye for beauty, whether in nature or in the artworks of man. A delightful modern Chinese painting, with its different shades of bamboo leaves, reminds me everyday of Weimin's friendship and of his vision of the world in the millinery scholar tradition."

— **Michel Davier**, *member of French Academy of Sciences*

"Weimin Wu is the author of a wonderful book which explores the 'Beauty of Physics'. His lambent photography is informed by a refined sense of aesthetics deeply grounded within his cultural framework. Indeed, he is both part of the next great wave of experimental exploration at the Large Hadron Collider and an interpreter of that exploration within the realm of beauty, symmetry and simplicity. Science is a profoundly human activity and the human sense of beauty is inextricably bound up with the quest for knowledge. These pellucid photographs delve deeply into those connections."

— **Dan Green**, *head of CMS Department, Fermilab*

"The photographs of Weimin Wu should forever put to rest the idea that idea that scientific ability and artistic aesthetics are mutually exclusive. Not only is Weimin Wu an accomplished scientist, but his photographs are evidence of his refined sense of beauty. His photography seems to be informed by his scientific knowledge. Not only does he understand the components, but he grasps the unity of the whole."

— **Rocky Kolb**, *Fellow of the American Academy of Arts and Sciences, and Professor of Astronomy and Astrophysics, University of Chicago*

"I am in complete agreement with Dr. Vidal's statement."

— **Leon Lederman**, *Nobel Laureate in Physics*

"I think that there are two aptitudes necessary for a successful scientist: one is curiosity, another is recognizing 'the connection between liberal arts and natural science'. I knew then that Weimin had rich literary talent besides being a physics student. Now, looking at his photos, I am convinced that the beauty of art and beauty of physics have natural connections. Mother Nature has more imaginative power than human beings.

In the current education system of China, some high schools separate natural science and liberal arts in order to get a higher acceptance rate to universities from their school. It is really a short-sighted plan that will hurt our young people in the long run. I think our education system has to produce students who are developing both talents, at least while still in high school.

Weimin's photo book shows an enlightening evidence for this connection. We eyewitness a clear example that success needs both artistic enthusiasm and scientific persistence, i.e., passion plus patience."

— **Guangjiong Ni**
Former Director of Institute of Modern Physics, Fudan University

"I do admire your photographic skills. One of the photos you gave me some decades ago still graces our walls. Good luck with your book and best wishes."

— **Jack Steinberger**, *Nobel laureate in Physics*

"While science is an explanation of nature, art is an expression of it. Weimin's photo collection combines the beauty of both nature and physics.

Symmetry is connected to conservation, and broken symmetry is connected to physics discovery. Symmetry is shown in the perfect reflection of a Japanese palace. The extra tree branches break the symmetry and reveal the correct orientation of the picture. This is just one example of his many photos showing the beauty of physics in an artistic manner. I particularly like the lines, curves, shapes, shadows and reflections in his photos, whether they contain flowers, buildings, mountains or the human body."

— **Saulan Wu**, *Fellow of the American Academy of Arts and Sciences, and Professor of Physics, University of Wisconsin-Madison*

"When the Institute of High Energy Physics, Beijing was founded, several talented young physicists were recruited and Weimin was one of them. We worked together in the building of the Beijing spectrometer since 1982. His warm love and great enthusiasm for physics strongly impressed me. In 1984, one day accidentally I caught a glimpse of several of his photos taken in CERN and I was much impressed by the beauty of his photos. Science and art are not two separate domains of human intellectual activities, actually they are different views of our world from different directions, and they are related rather closely. From his book, I hope readers will discover how beautiful physics is and a physicist can at the same time also be an artist. I appreciate very much that Weimin introduces us to the beautiful world of physics through his book, *Beauty of Physics*."

— **Minghan Ye**, *member of the Chinese Academy of Engineering, and Scientific Director of China Center of Advanced Science and Technology*

"A physicist by profession, Weimin Wu is also an avid nature photographer who enjoys an all-round living. He has never ceased to be amazed by the rules of physics forces and motion, but he also has a penchant for all kinds of physical beauty. Hence, while he is fascinated by the wonders of the microcosmic world, the economic and social development in the macrocosmic world has always remained close to his heart.

His ingenuity to combine art and science has enabled him to produce many photographs cleverly depicting light and shadow. With his physics training and unique insights, he has captured the imagination of many people, photographing countless seemingly ordinary events or objects. Wu's photographs are truly the perfect embodiment of nature's beauty, goodness of life and harmonious relations. Those wondrous and spectacular images are sure to entice the curious minds, and inspire many to want to pursue a career in science research and explore the social or natural order of the universe.

Weimin Wu is indeed a learned man with vast interest. Not only does he possess a great zest for life, his impressive photograph collection will prove to be invaluable to anyone, be it an entrepreneur or a young man, who may be in search of an enriching and fulfilling experience."

— **Guangsheng Zhang**, *President of Shanghai Pudong Development Bank*

Preface

Some twenty years ago my photograph *The Birth* won a First Class prize in a contest held under the auspices of the European Organization for Nuclear Research (CERN). I was also given the privilege to display some of my other photos in the main lobby of CERN. It gave me great pleasure to invite my good friend Sally Alderson to view them. (Sally is a British journalist. She wrote the preface for the renowned photographer D'Albert Philippon's photo collection of Léman and Geneva.) While I was waiting for her in the lobby, another Chinese man was looking at the exhibition. With a smile, he approached me and asked if I knew the prizewinner. This person turned out to be Dr. K. K. Phua, the founder and chairman of World Scientific Publishing. We have become close friends since that day.

Twenty years have gone by in a wink. Today World Scientific is one of the leading international publishers, and it is especially strong in the area of high energy physics. And I had moved to the US to work at the Fermi National Accelerator Laboratory as a researcher.

In the intervening years many things have changed, but my enthusiasm for photography remains the same. To me physics and photography are like a pair of twin sisters. Physics stresses elegance. There is no formula in the world as elegant as Maxwell's equations. Physics is also concise. There is no expression in the world as concise as $E = mc^2$. Photography is precisely the unification of beauty and conciseness. The key to photography lies in the application of physical principles: lighting, layers, contrast and color spectrum are the soul of a photograph, and the control of time exposure determines its theme. Of course luck also plays a role in the making of a good photo. Surely a perfect rainbow in the desert is not an everyday event. But then, isn't it the same in physics? New physical phenomena are often discovered most unexpectedly. In fact, there is one more similarity between physics and photography: luck is granted only to those who are prepared. The wonders of

nature only happen at a specific time and place, and it is easy to let them slip through one's fingers.

I would like to thank Professor K. K. Phua for providing me with the opportunity to publish this collection of photographs. I am also indebted to Prof. David Kiang, Tan Hwee Chiang and the staff at World Scientific for their invaluable assistance. I am deeply grateful to Dr. Richard Vidal for writing the Introduction. I would also like to express my sincere thanks to a great calligraphy master Yiqing Liu, the Vice President of the Chinese Calligraphy Association, who wrote the beautiful calligraphic form of the book title in Chinese seen on the front cover. It is not possible to list all my friends who have provided me with encouragement throughout this project. To all of them, I would like to say "Thank you." My effort is amply rewarded if the reader has gained from this book a glimpse of a physicist's view of the beauty of nature.

December 2006

Contents

Landscape

People

Beauty of Physics

Introduction

Over the past 180 years, photographs have helped us learn much about the natural world. From the first photographs of animal motion, to the expansion of the universe, from the first x-rays of the human body to untangling the structure of DNA, from bubble-chamber pictures of fundamental particles to the weather pictures of hurricanes taken from space, photography has been an important and prolific tool in uncovering the workings of nature. In many instances, it has been indispensable.

But in parallel, soon after photography was first demonstrated, people recognized that it could be used to create art, great art, a new form of visual art that was not possible before. Like painting and sculpture, it allowed people to create visually striking works of transcendent existence. Its ability to render a physical likeness was soon transformed and adapted to produce images as significant as any that had been created before. From the early photos of Nadar in Paris to Gordon Park's exposition of the black experience in America, from the odd angles of Rodchenko to the western majesty in an Ansel Adams landscape, from Brassai to Mappelthorpe, photographers have created unique images that express the human experience and worlds that no other artists had made before. And photography is still young, with many new paths to explore as the technology improves and expands.

Photography is unique in the way that its use and development in art and science have proceeded in parallel, often at a breathtaking pace. Art and science sometimes are considered as two distinct human activities with little or no overlap. However, many gifted people are able to see the parallel development of art and science as part of the same whole. One such person is Weimin Wu. While engaging in some of the most difficult and rewarding science in particle physics, on another day, he creates impressive and appealing images with his camera. The context of his photographs may be the natural world he loves, but his expression is singularly artistic and creative.

Starting at age 12 in China, using a camera borrowed from his uncle, Weimin learned early how to express his visions with images. At Fudan University, finally able to purchase a camera of his own, he shared his pictures with his fellow students at the photography club. The new camera came with a price however. It meant walking from the University to home, instead of taking the bus. When he received his degree in physics, he was able to afford more time and money to further his development. But the upheavals in China interrupted his plans.

To make great photographic images, talent is necessary, yes, but life's experiences can mold that talent into an ability that can achieve far more. Like a Chinese version of Pasternak's Dr. Zhivago, Weimin Wu absorbed the images of the great events around him. His images were shaped by the events he witnessed. Banished to the rural China countryside as a shepard to appreciate the hardship and struggle of the proletariat during the extremes of Mao's Cultural Revolution, Weimin Wu gathered not sheep, but the impressions and influences that would serve his image-making later, turning injustice to his advantage. Somehow he survived the hunger and loneliness to return to the University to resume his career in science.

Just as Zhivago's practice of medicine did not deter, but enhanced, his poetry, so did Weimin's career in science add to his photography. As a leading scientist and administrator in China he served the Chinese people well, contributing significantly to the growth of physics there. But a person of his ability cannot resist the scientific advantages of the West forever, and he finally engaged his lifelong passion for science by participating in the great on-going scientific enterprises in Europe and the United States. Soon after his relocation in the West, which came through the intercession of Jack Steinberger at CERN, he won first prize in a photographic competition in Geneva, Switzerland and members of the scientific community became aware and appreciative of his talent for image-making.

Because Weimin is a working particle physicist, he has a different perspective from most when creating photographic images. Particle physics is not about laws and rules that nature follow, but rather about the ideas behind the rules and laws, and how the rules and laws are derived from the ideas. Symmetry, interaction, geometry, and identity are just some of the ideas that a particle physicist studies via their expression in nature. To an image-maker, these are also important concepts that most photographers use and exploit instinctively. A particle physicist like Weimin has studied and explored these ideas in nature explicitly, and they are overtly incorporated into his images.

For example, to a particle physicist, symmetry is the most crucial concept. But physicists generalize the idea to more than just reflections in a lake **Lost in Reflection**, **What a Splitting Image**, **Shangri-la**, or the symmetry of a starfish. To them, symmetry is about likeness and similarity. If a change is made (a rotation, a mirror-image, an inversion, etc.), then things basically stay the same, or at least look the same. But there is an even deeper concept — two things may seem unrelated but through a transformation or morphing they can be shown to be behaving identically. In essence, to a particle physicist, that is what the equivalence in mathematics is all about. Weimin uses to great success his understanding of these intellectual ideas inspired and learned from particle physics in composing and creating the images in his photographs.

The pictures in this collection represent some of the best photographs Weimin Wu has created over the years. Surely, from studying nature, a physicist like Weimin Wu can understand how the diffraction and polarization of light can produce the shimmering water in **The One and Only**, Or, that he is cognizant of the psychological effect on people of juxtaposing red and green, or blue and yellow colors in a photograph. But it takes a truly creative person to compose and conjure the other-worldly image of **The One and Only** into existence, as Weimin does in this photograph, producing an image of alluring appeal with its silkiness. The radiant loveliness of **Flame of Paradise** is further multiplied by the inner glow that seems to emanate from the center of the flower. It takes more than a mere knowledge of light's properties to capture and create such a photograph. Consider what is the source of heavenly light that illuminates **Prima Beauty**? And what life is about to emerge from the conical pod at the center? Is there a more exquisite pink that can found in **My Fair Lady**, with the blue-black water behind? Weimin's clear mastery of light is evident throughout this collection.

Dr. Richard Vidal
Fermilab

The Person Who Sent Out the First e-mail from China: The Scientific Career of Weimin Wu

Today the world has entered the internet age. Electronic mail and webpages are displacing traditional mail, newspapers, and magazines. One of the most important achievements that took place in the 20th century was the birth and development of information science of which computers and internet communication are the two very pillars. To coincide with the 50th Chinese National Day, an article was published listing the many "firsts" achieved brilliantly in science and technology in the preceding 50 years: the first atomic bomb, the first artificial satellite, the first electron-positron collider …. However, when was the first computer network for global communication set up in China? And when and where was the first e-mail, an important characteristic of the information era, sent in China, and where to and by whom? It can be said that the first e-mail from China was sent abroad on August 25, 1986, by Weimin Wu of the Institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences, who at that time was a Chinese group leader of the ALEPH collaboration, working with Professor Jack Steinberger at CERN (European Organization for Nuclear Research) in Geneva, Switzerland. Here let us review the history of this event, and also introduce Weimin Wu, a legendary figure in science. He is the only scientist from China who has participated in three different fields of scientific work: the first atomic bomb project, the launch of the first artificial satellite, and the construction of the first electron-positron collider. He had a storybook-like experience during those 50 tumultuous years, and unforeseen circumstances made him the only Chinese scientist to take part in the three high-tech engineering projects which were the pride of China.

To some extent, his experience is also a microcosm of China's history for the past 50 years.

1. The First Computer Network in China for Global Communication

This part of the history began in 1979. That year Professor Tsung-Dao Lee came to China to lecture on high-energy physics. His objective was to bring those researchers in high-energy physics from isolation directly to the frontier of the field. He worked tirelessly and lectured until his voice was hoarse. He left an unforgettable impression on the more than three hundred young scientists and university teachers who attended the lectures from all over China. This was the first time since the Cultural Revolution that self-isolated Chinese scientists became enlightened. "Spring was in the air" in the lecture halls. Weimin Wu was fortunate to be one of the attendees. Afterward, with arrangements made by Professor Lee, about thirty scientists who were in their prime at IHEP were selected via the examination mode to do research at the frontiers of knowledge at the best high-energy physics research institutes and universities in the world. Wu, then 36 years old, was selected and sent to CERN. He joined the CDHS neutrino research group led by Nobel Laureate Professor Jack Steinberger. Wu returned to China in early 1982. During his two-year stint at Geneva, from his viewpoint, the greatest benefit was to have established a connection with the top scientists in the world working at the cutting edge of physics, and to have been enriched with the experience gained in a world-class research environment.

Not long after Wu's return, the CDHS group ceased operation. Using it as a foundation, a new research group ALEPH was formed. This was an experimental group, again under Professor Steinberger's guidance, working at the newly completed LEP, the world's highest energy electron-positron collider. (Recently this group has also ceased operation. Subsequently the CMS and ATLAS groups have been formed for the world's highest energy proton-proton collider (LHC). Wu is currently involved in research in the CMS group.) From 1982 to 1983, Wu was busy at the Chinese Academy of Sciences, IHEP and the National Natural Sciences Foundation of China, trying to gain support to establish the ALEPH group at IHEP. At the same time he maintained contact with foreign scientists in the ALEPH group. Finally, in April 1983, the Chinese group led by Wu formally became a member of the ALEPH Collaboration. The Beijing ALEPH group was responsible for the construction of part of the detector for muons at the end cap, as well as the muon detectors for the entire outer layer. As of today, this is still one of the largest detector parts built in China for experiments carried out by an international collaboration.

Construction of detectors is merely a means, whereas physics research is the end objective. In a multi-national scientific collaboration, a computer network is essential for communication and data transfer. In 1985, Steinberger asked Wu to look into the feasibility of setting up a computer network between CERN and IHEP in Beijing, and he also requested that Dr. Palazzi of the data handling department at CERN work together with Wu.

Communication using computer network was in its infancy at that time, and in China only very few had realized its importance and potential. Therefore Wu encountered tremendous difficulties in his endeavor. There were not only technical difficulties, but also political, administrative, financial and conceptual ones. Would the political security department allow direct online communication with foreign countries? Would the primitive telecommunication system in China be able to handle the technical requirements? How would the expensive communication cost be paid? How to manage the network routing? All of these were difficult problems. Fortunately, the director of IHEP at that time, Professor Ye Minghan, strongly supported Wu's work, and his backing enabled the construction of the computer network to be included as an item in a nationally designated elite engineering project, the Beijing electron-positron collider (BEPS) and Beijing spectrometer (BES). Thus the development of the computer network was assured of political, personnel, and financial support.

The final arrangement made was as follows. A small shielded room in the BES building was provided to house a computer terminal, which served as a remote terminal. This terminal was connected to another computer at "710" Institute. The wireless connection was done by means of an ultrahigh microwave frequency communication device and the antenna on the rooftop of the main building of IHEP. This ultrahigh microwave frequency communication device had been first established and successfully tested between IHEP and the Institute of Hydroelectricity in July 1984 by Wu et al. The 710 Institute was connected to Vienna Broadcast Station in Austria via satellite and from there by telephone line to CERN. In setting up all these links, unforeseen problems arose at every step. For the installation and use of the ultrahigh frequency wireless communication device, approval had to be obtained from the committee on the management of wireless communication and also from various security departments. Harmonious coordination with 710 Institute, the Ministry of Post and Telecommunication, Vienna, CERN and numerous units, appears unimaginable even today, let alone during the time of a far less open era. How all these were achieved in the past is difficult even for Wu himself to recollect. Hard work does not disappoint those who

are determined. Finally, on August 25, 1986, Wu sent the first e-mail from Beijing to Professor Steinberger at CERN using remote login mode.*

Of course, the first airplane built by the Wright Brothers was primitive and crude, but it did fly. Likewise, this first network was laughably slow. There was a time delay between when a key on the keyboard was struck, and the appearance of the alphabet on the screen. Nobody today would be able to accept that kind of speed. Nor can anyone remember the long e-mail address of IHEP. However, all these led China to the first step towards the internet world.

2. Participation in Making the First Atomic Bomb in China

Unusual history provided unusual opportunities for Wu.

In 1960, Wu had just turned 17 and graduated from high school with distinction, achieving full marks in all his subjects. Later, he excelled in the nation-wide university entrance examination, and was selected to study in the Soviet Union. At that time, for children of ordinary citizens to be picked to study in the Soviet Union, they had to be outstanding. Wu was one of those lucky ones.

While he was waiting excitedly for the start of a Russian language training course, strange things happened. Classmates had gradually began their new university classes. However, although it was then already September, there was no information about the Russian language training course. Not until in early October did Wu find out the reason. The plan to send students to the Soviet Union had been canceled for that year, in view of certain developments on the Soviet side. To study abroad was then such a sweet dream, and the dream was destroyed just like that for Wu. Soon afterward Wu and 14 other students who were supposed to be sent to the Soviet Union received a notification from the Department of Atomic Energy at Fudan University. These 15 students would form a special Section "Zero". Each year, incoming students to the Department of Atomic Energy at Fudan were normally divided into four sections: two

*China Internet Network Information Center (CNNIC) recently updated their record of "milestones of early internet development in China" verified by a special committee which stated: On August 25, 1986, Weimin Wu from the Institute of High Energy Physics, Chinese Academy of Sciences, used a PC located in the Beijing Institute of Information to send an e-mail by remote login mode to Prof. Jack Steinberger (Nobel Laureate in Physics, 1988) at the European Center for Nuclear Research (CERN), Geneva, Switzerland. This is the first e-mail sent out from Mainland China as far as all records show.

specialized in nuclear physics, two in radiation chemistry. This Section "Zero" was then creating an atmosphere of mystery to the whole campus.

Events even more mysterious happened. Yang Xiguang, who at that time was the secretary of the party committee at the university as well as one of the party secretaries for the Shanghai city committee, called a meeting with Section "Zero". He announced a "special mission" and "special discipline" for them: participation in a research project to make China's first atomic bomb, and he issued strict orders to them to maintain absolute silence on this matter with their families, teachers and students at the university. In this manner, history engulfed these 15 teenage university students in a top secret national mission. During the day, they had to take classes like all other students. In the evening they went to a mysterious, white, large building in the Department of Atomic Energy to do research. Clearly they carried a heavy burden.

It is well-known that the principle involved in making an atomic bomb is simple, but the technical problems are complicated. For the chain reactions to reach the stage of an atomic explosion, enriched nuclear fuel is required. In natural uranium, ^{238}U is the main isotope. However, the isotope that is responsible for the chain reactions is ^{235}U, which only amounts to less than one percent in natural uranium. Therefore to make an atomic bomb, natural uranium must be enriched. An increasingly higher degree of enrichment will produce a bomb of more power, or one of a smaller physical size.

^{238}U and ^{235}U are very similar in physical and chemical properties; they differ only in the number of neutrons they contain. How to make natural uranium enriched in ^{235}U? This is a top secret. Some national laboratories and gas diffusion facilities in the United States were the pioneers in this kind of experiments. All those Chinese scientists returning from the Soviet Union knew was merely that the same technique was used in the Soviet Union. Perhaps at that time the gas diffusion method was the only one known in the industrial-scale enrichment of uranium. Not to be accused of "leaking secrets", we will sketch the method only briefly here.

Gasified uranium compound is made to pass through a chamber with a difference in pressure between the front and back sections. The chamber is separated into two parts in the middle by a permeable membrane. Since the atomic weight of ^{235}U is smaller, the probability of its transmission through the membrane is higher than that of ^{238}U. This separation is the first step towards enrichment. Repetitive application of this process eventually leads to the desired concentration of nuclear fuel. Therefore a crucial component in making an atomic bomb is the permeable membrane. Its quality determines

the efficiency of the concentration process, which in turn determines the quality and quantity of the enriched uranium.

Two approaches were pursued by this secret research group in the Department of Atomic Energy at Fudan University. One used the powder metallurgy method, that is, particles of certain anti-corrosive, gasified metal of a certain size were sprayed onto another metallic membrane of a certain strength, density, and spacing under high pressure and high temperature. No theoretical calculation was available as a guide to fix all the parameters properly. Progress entirely depended on repeated trials, tests and measurement. The other approach was the chemical sedimentary method. A certain metallic compound underwent a chemical reaction to yield the metal as sediment. The sediment was then made to crystallize onto a certain metallic membrane, and further chemical and physical manipulation was applied. Of course there were many details involved. What has been sketched here is all within the scope of some articles in a popular science magazine. Nevertheless this already suffices to show the difficulty of this research. Wu participated in these two approaches at the same time.

Slightly more than a year later, good progress had been made in the research work. On the other hand, that was the beginning of the three-year period when China had severe famine. Universities began a policy to lessen the load of students. Those 15 students in Section "Zero" were attending classes during the day, and doing research at night, and were not even well-fed. After a year, most of those "genius" students began to have difficulty to keep pace in their studies with students from the other sections. Under these circumstances, Section "Zero" was disbanded. Those 15 students, originally destined to study in the Soviet Union, were then made to join the other four sections. Wu was assigned to Nuclear Physics Section 3, and started a normal university life. However, his experience during this period added a memorable chapter to his life. When the Chinese were elated at the announcement of the first atomic bomb test in 1964, Wu was wondering to himself whether the permeable membrane he was involved in its making was used. This is still a national secret, and thus remains a permanent puzzle for Wu. Now Wu is a resident and citizen of the United States, and he works in an American National Laboratory. Of course he has many opportunities to go to Oak Ridge National Laboratory for conferences. Somehow, he has never had the desire to go there. Let Oak Ridge, a name he had heard when he was 17, remain a puzzling place. He does not want to solve the puzzle, because puzzles make life more colorful.

3. Participation in the Launch of the First Artificial Satellite in China

In April 1970, the launch of the first artificial satellite in China was the second achievement in science and technology that shocked the world and brought glory to China. Wu was fortunate to be a participant in this project. His opportunity came again as a result of certain special historical events. Around the world today there are many leading high-energy physicists who have taken part in the development of atomic or hydrogen bombs. This is not surprising because high-energy physics was developed from the foundation of nuclear physics. On the other hand, guided missiles and artificial satellites are completely unrelated to atomic and hydrogen bombs. How did Wu get involved with guided missiles and artificial satellites? His experience during this period may be said to be a miniature picture of the many disastrous, sad, and terrible events which occurred in China at that time.

In 1965 at the age of twenty-one, Wu graduated from Fudan University as one of its youngest graduates. After sitting for the examination, he was accepted as a graduate student by the Department of Modern Physics at Lanzhou University. At that time, a directive of quality over quantity was in force, thus there were very few graduate students. It was estimated that between 1949 and 1965, the total accumulated number of graduate students in all disciplines in China was only a little over 5000. During the Cultural Revolution, graduate students were judged to be the top of the revisionism education pyramid, and they were important targets for the so-called "re-education" by workers, farmers, and soldiers. At the same time, the success rate of admission to graduate schools via examinations was perhaps only one in a hundred. This became a justification that those graduate students had to be seriously "re-educated". What a preposterous proposition!

After the break up in China-Soviet relations, most Chinese scientists returning from the Soviet Union, following Mao Zedong's directive of the so-called "3 lines construction", went to Lanzhou and some other places in the mountainous area far away from the coast. Lanzhou University became one of the Chinese centers and bases for nuclear research.

Wu left metropolitan Shanghai and went to Lanzhou which is surrounded by barren mountains. He was filled with excitement and hope for a brilliant career ahead. No one could foretell neither a "cultural" nor "revolutionary" disaster was soon to begin. Soon after his arrival as a graduate student, Wu was sent to the Dingxi mountainous region, one of the poorest areas in China. There he lived in a cave, isolated from the world, and worked as a shepherd.

Food consisted of potatoes and wild vegetation, and water was collected from the rain and snow. More than once he almost perished. In one dangerous situation, he had to escape from a predatory wolf. In another he was bitten by a shepherd dog and the swelling wound on his thigh caused serious infection. Amazingly he survived without any hygienic and medical care. Once he also survived from the collapse of the cave where he lived. Perhaps it was God's will to save this scientific genius for China.

Many talented persons in their prime were wasted, tortured and destroyed in this period of utter absurdity.

Later under the so-called "universities must carry on" guidance, the then frail and bony Wu returned to Lanzhou. His supervisor, Prof. Xu Gongou (who later became the president of Lanzhou University) was accused of being an authority in reactionary scholarship, and a landlord slipped through the net. He was assigned to clean toilets. "White" horror and "red" horror swept through Lanzhou, and all of China.

To control the chaotic situation, a military regiment was stationed in Lanzhou University. The leader was political commissar Wang Shaoren. He was de facto a scholarly officer, and he deeply appreciated talents. Soon he discovered Wu and his outstanding abilities. Although at that time Wu's parents were labeled as capitalists, Wang tried by all means to transfer Wu from the chaotic Lanzhou University to a better place.

In spite of Wang's best effort, however, in the end Wu was sent to the "corp of construction unit" under the so-called "re-education" policy. So instead of a shepherd's whip, he had a shovel for digging. All day long he had to handle bricks, cement, explosives and sand paste. One wonders what reeducation during the Cultural Revolution had done to Chinese scientists. It was one of the most terrible and dark eras in modern Chinese history.

A historical event near the end of 1969 brought opportunities. China was preparing to launch her first artificial satellite. However, there were very few technologists who were competent for this project. Wang Shaoren was once the political commissar at the data processing station at the base, and he immediately thought about Wu who was in the "construction unit". Even though Wu's background was in nuclear physics, and he had been isolated in remote regions and the Gobi desert for quite a few years, Wang had confidence in Wu's ability and solid foundation in physics, and he believed Wu could become familiar with the project quickly, and to fulfill his assigned duties.

In view of Wang's recommendation, Wu was appointed to do data telemetering analysis for the control system. He was responsible for the data processing of the control system of the last stage rocket which sends

a satellite into its orbit. Its control system is very important with regard to various quantitative characteristics of the orbit. After merely a few months, Wu completed his assignment. In this historical event, there were reports of data processing and analysis signed by Wu. A certain instrument developed under his leadership was awarded the National Science Congress Prize in 1978, adding a perfect ending to that chapter of his life. Thenceforth his life would turn to a new page.

4. Observation of the First J/ψ Particle Produced in China

The National Science Congress held in 1978 resulted in the rejuvenation of science in a slumbering China. This ancient civilization was again aglow with youthfulness under the policy of the central government that "science and technology is number one for productivity", and "intellectuals are part of the working class". Under such circumstances, China decided to build a high energy accelerator. The initial plan was to build a 50 GeV proton synchrotron. Manpower is the deciding factor. The dream of previous generations of Chinese physicists to build an accelerator then depended on the present generation to realize. But in 1978, just after the Cultural Revolution, where could one find all the required personnel?

To fill the gap, several talented young physicists were recruited by the national planning committee, and Wu was one of them. Subsequent events had already been described at the beginning of this article. In the following let us turn to the Beijing spectrometer (BES).

Deng Xiaoping said China must have atomic bombs, hydrogen bombs, artificial satellites and guided missiles. Without these, a nation is a nobody in the world. And China must also be involved in high-energy physics, for China must have a place in the realm of high technology.

The revised plan for the advancement of high-energy physics in China settled on constructing an electron-positron collider in Beijing. Before 1985 Wu was only a group leader of the Chinese participation at ALEPH. He was not involved with the work at BES. Professor Xiao Jie, a consultant to the Beijing spectrometer, had realized that computer software, data collection and analysis were the weak points of the project at BES. He urged Wu to join the BES group. Professor Ye Minghan, the Director of IHEP and chief of BES, himself talked to Wu several times and even visited him at home. He wanted Wu to be a vice division director at the BES, in addition to his position at ALEPH. Wu would be in charge of the online data collection, and off-line data analysis.

The engineering work at the Beijing Electron-Positron Collider was essentially completed by October 1988. Commissioned runs were in progress, before the handover to the government. However, during the commissioned runs, the J/ψ particle, a benchmark for a successful run of BES, had not been observed.

The J/ψ particle was discovered in 1974 (Professor Samuel C. C. Ting was one of the discoverers, and was awarded the Nobel Prize for this discovery). If the construction and operation of BEPC and BES had satisfied the required specifications, the J/ψ particle should had been observed.

However, as Professor Ting said, in scientific and technological competition there is only a number one, but no number two. Being number two is effectively the loser. Nevertheless, a J/ψ particle observed at the BES would be a definitive manifestation of a successful operation.

The appointed date for delivery and inspection by the central government was fast approaching, but the J/ψ particle had still not been seen. Professor Ye, Professor Zheng Zhipeng, the division director of BES, and other leaders decided to adopt an intensified action plan. Division directors and section heads were divided into three shifts, working non-stop to find trouble and solve problems. One night Wu, as a deputy division director of BES and a section head Zhang Changchun were on night shift duty. Zhang once worked in Ting's Mark-J group (in Hamburg, Germany), and therefore was a physicist with the relevant training and experience. After inspection, he concluded that the reason for the failure to observe the J/ψ particle was that a certain crucial part of the spectrometer was not operating properly. Voltage had not been raised high enough to the trigger point. Wu agreed with his assessment. However, there was difficulty and risk in increasing the voltage. The quality of that crucial part was not very good, so higher voltage might cause some channels to break. The conventional thinking at that time was to exercise extreme caution — avoiding mistakes was preferred to making risky improvement. Therefore no one dared to increase the voltage. Wu told Zhang that the BES was meant for scientific work, and it was not an exhibition piece for the public. What was the use of operating the machine if it could not reach the trigger condition? That would be simply a waste of time and energy. Wu told Zhang to increase the voltage gradually, and he would take full responsibility. With this assurance, Zhang gradually increased the voltage until it finally reached the desired operating range. Though there were a few broken channels, that specific part did work properly and the trigger condition was achieved. By then it was well into the night. The first J/ψ particle produced in China at last appeared on the screen of the computer

at 11.00 pm, 22 June 1989. Wu and Zhang recorded the event, and excitedly telephoned Zheng Zhipeng and Ye Minghan at home. Soon many experts rushed into the spectrometer operation control room, and confirmed the event recorded by Wu and Zhang. Wu recorded the experimental observation and process in the official log book and drafted a report to all the people in the institute. The next day, an air of celebration filled the whole of IHEP.

5. Digression (but not irrelevant)

Wu was lucky. Both due to a strange combination of circumstances, or occasional opportunities, he became the only Chinese to participate in three top scientific and technological projects — the atomic bomb, the artificial satellite, and high-energy physics.

Wu was also unlucky. He was born at the wrong time. According to Wu himself, as far as the three projects were concerned, all he did was to participate. He did not make any contribution that deserved praises. He said when one dies, it is best to leave a legacy. Newton's three laws, Einstein's theory of relativity …. These are the valuables left with the treasury of human knowledge. Even the completion of the first global computer communication network in China was something already done abroad, and was nothing to brag about.

Wu's real ideal is to seek answers to the most fundamental questions in the universe: what is matter? What is mass? What is electrical charge? Where do they come from? The adage "ten wise men cannot answer the question raised by a fool" comes to mind. We are now in the 21st century. The question "where does mass come from?" may seem stupid, but it remains a puzzle to the leading scientists of the world.

When Wu was 18, he wrote a paper entitled "On Zi and Dian". He proposed that all particles are made from two fundamental particles: one he called "Zi", the other "Dian". The fundamental particle "Dian" is the source of electrical charges, and it also provides the "electromagnetic mass". The fundamental particle "Zi" is the origin of "particles", and it provides the "gravitational mass". The two are connected by an unknown "field". All particles in the world are "composites" of these two fundamental particles.

Wu's paper came to the attention of his teacher Ni Guangjiong, who complimented him. Ni was the ex-director of the Institute of Theoretical Physics at Fudan University. In 1986, Ni encountered Wu at Uppsala, Sweden during the annual European High Energy Physics Conference. He attended a keynote talk by Wu presented on behalf of IHEP on the status report of BEPC

and BES. This talk was one of the earliest presentations for BEPC and BES at an international conference, and hence it was in a way an announcement that China had then joined the international community of high-energy physics. At the conclusion of the talk, Wu received warm congratulations from the audience, including Nobel laureates and many world-renowned scientists, and directors of research institutes. Of course the honor belonged to the Institute of High Energy Physics, Beijing. Afterward, Ni wrote that in his decades of teaching, having taught more than a thousand students, Wu was among the best of them.

Just as Wu was ready to climb to the apex of science, overnight he was transformed from a graduate student into a shepherd, as described in a previous section. And also just at the time he was a shepherd, the quark model came to the world. According to this model, all hadrons are composed of three types of fundamental particles, called quarks. These quarks have definite mass and electrical charges. Many known particles at that time can be accounted for in this model. This success formed the basis of what is known today as the "Standard Model". When the J/ψ particle was discovered in 1974, the three-quark model required extension so the fourth quark (the c quark) was introduced. Later, a fifth quark (the b quark) and a sixth quark (the t quark) were discovered at Fermilab in the United States, where Wu is now. There the search for the Higgs boson, the only missing particle in the "Standard Model", is ongoing. Wu is fortunate again to be involved in the search for the Higgs boson.

Many Chinese have always raised the question why in all these years China has not produced a Nobel laureate whose scientific discoveries were made within the country. Readers naturally can find the unspoken answer from Wu's experience.

People have often asked Wu about his success. Wu's answer is "I am not successful, because I have not achieved much." Some have labeled Wu as a "prodigy", or "genius". Wu has always said he is not a genius at all, and at most he is merely a person of some ability. He frequently maintains that the objective of going to school is to learn how to learn. This is because the schooling period in life is so short, yet knowledge is without boundary. The important thing is to know the method of learning. Whatever is not known one can then proceed to learn by oneself. It is usually said that there is no poor student, only poor teachers. Wu thinks the opposite is true: there is no poor teacher, only poor students. There is some rationale in saying that Harvard is so good because it has the best students. In many of the scientific and technological projects in which Wu participated successfully, he was

mostly learning on the job. His photography has won prizes in Europe. He has written numerous articles, novels, reports, and travel logs for newspapers and magazines. He performed in the "Yellow River Chorus" at the Chicago Symphony Hall. He was awarded medals in the sports meet at Fudan University. Some even claim that his cooking is better than the professionals. All his hobbies were also self-taught.

Wu was asked if he had thought about the Nobel Prize. He said he might have done so forty years ago, but no longer. T. D. Lee, C. N. Yang, S. C. C. Ting and others did their Nobel caliber work before their early thirties, whereas he only started his career as a high-energy physicist in his thirties due to the disruption caused by the "cultural revolution" in China, with even less preparation than a typical university student of that time. For him the Nobel Prize is a dream lost forever.

Wu likes to challenge issues described as "authority", "number one", "never happened before", or "impossible". At present he is in the CMS group, involved with the search of the Higgs boson, the last unfound particle in the Standard Model. Its discovery may lead to a Nobel Prize. As for Wu, he said "This is a great career, but for me it is also more a way of making a living."

Wu's remark carries a somewhat pessimistic tone. But facts may bear him out. China has a population of over one billion. There are plenty of talented persons. Many golden phoenixes have flown out even from remote and poor regions. Wu published a novel in 1986, with the title "The dark shadow of first love". It is a story about his first lover. The story has a quiet beginning and a melancholy ending, and it has influenced his life profoundly. When Wu was in his teens, he knew a little about electromagnetism. He thought if one installed a generator at a wheel of an automobile, one could use the electricity for illumination. After he had learned some thermodynamics, he thought if a heavy ball was used as a valve for a high pressure chamber, then the ball would spring up if the pressure exceeded a certain limit, thus acting as a safety valve. When his teacher told him that all these had already been done, Wu felt as if he were hit by a staggering blow. After this incident, Wu swore that he must get to the unknown frontier. In fact, dark shadows are produced not only by sad first loves. The era that destroyed the talents of many also had cast a dark shadow over them for a lifetime. There is a lesson and enlightenment to be learned from the experience of this unusual person in the scientific world. We must appreciate talents, discover talents, nuture talents, and make use of talents. If science can have such a spring, a golden autumn with plenty of fruits will surely arrive!

My Picture Stories

For any aspiring politician, artist or scientist, their success depends on a number of factors. Besides being truly gifted and highly industrious, he or she must also be unusually lucky. The same holds true for physics experiments. Take my work at Fermilab for instance, our research team is currently working on the Compact Muon Spectrometer (CMS) Experiment at the Large Hadron Collider (LHC) at CERN. Our success will be determined by a number of factors. Firstly, there must be absolute clarity regarding physics reasoning and the detector parameters must match the demands of the program; Secondly, the team working on the experiment must be highly driven and meticulous. But ultimately, it is still very much in God's hand. The search for the standard model particle Higgs is one of the major objectives of the CMS team. To accomplish our mission, we have created a near-perfect detector to trace all possible paths of the Higgs particle, and have more than one thousand physicists and engineers working round the clock. But it is anybody's guess whether we will achieve our goal. For the Higgs may never have existed. Or its mass may be beyond the reach of LHC. So if Mother Nature is not on our side, no matter how flawless our detector may be or how hard we try, we would never get anywhere nearer to the truth, although someone once has said: "it may be more exciting eventually if the Higgs is not discovered."

Turning to the art of photography, the same conditions also apply. Taking a picture is not unlike running a small scale optics experiment. To start off, you must of course identify a theme and get a functional camera. But more importantly, you must have the passion and patience, as well as the determination to achieve the best results. The rest is, as they say, up to Lady Luck. Because, you see, some of the world's truly exceptional photographs are really the work of Nature rather than the work of men. Let me illustrate this by sharing with you the stories behind my pictures shown in this book. The stories are grouped under three different categories.

1. The Beauty of Physics

A camera is an uncomplicated optical instrument with lens shutters and media recording devices. Like any high energy physics experiment, the physical properties are the determining factors of the end result of each photograph. The most common performance indices of a camera include: aperture dimension, zoom zone, shutter speed, chromatogram response and camera lens, etc. To become an expert photographer, you must first understand some basic principles in physics, because only by successful application of these principles will you be able to produce photographs with beauty and soul.

When you enter a garden in its full glory, I am sure you will thoroughly enjoy its grandeur and beauty. And beauty comes in different forms. Some people may appreciate a delicate single bloom while others are most captivated by a magnificent sea of vibrant flowers. If you look at the contrast between the slender cereus and barrel cactus, against a foreground of brightly colored flowers in **A Pebble Nursery**, the effect is amazingly vivid and intimate. The width of view was expanded by using a wide-angle lens. A zoom out shot, on the other hand, has worked wonders for **Tulips Rule** and **Blooming into Infinity**. The breathtaking display of hundreds of thousands of tulips are enough to impress anyone. When it comes to taking pictures of a single object, like the surreal yet familiar ambience presented by **A Thorny Encounter**, you have to adopt a totally different approach. Another example would be **Layer to Perfection**. A close-up shot works best for highlighting the refined layering of the peony. So when you take pictures of such a gorgeous flower, use the zoom feature to showcase its delicate petals. It is easy to appreciate its beauty when you play up its features.

The lotus may be one of the most photographed flowers, but rarely do you come across a blossom as perfect as the **Prima Beauty**. It was in full bloom, with fresh pistils, a ripe seed pod and all petals intact. It kind of reminded me of a motherly figure who still retains her youthful good looks after giving birth. It really makes one wonder what are her beauty secrets. In Chinese poems, the lotus has long been regarded as a symbol of purity and goodness, untouched by evil. By darkening the background to bring out the pureness of the lotus blossom, the "chaste" effect was created with clever use of exposure control. It is impossible to achieve the same effect using automatic exposure. Besides the lotus, the duckweed also makes a good photography subject. Just look at the confetti-like layout in **Spreading with Joy**, it sort of resembled a casual display of precious stones. For **The One and Only**, the flower, the leaves as well as the water were all prominently featured. Using a

small calibre projectile and slow shutter speed, the lotus and the leaves were distinctly illuminated while the water was silky smooth. It looked almost like an oil painting. **My Fair Lady** was taken with a telephoto lens. By manually controlling the exposure level, the softness of the background made a perfect setting for the pink lotus.

For flower or garden photography, do not limit yourself to taking only pictures of exotic or spectacular flowers and plants. Under a microlens a tiny leaf or a young bud may looks just as amazing. All it takes is a sharp eye and a creative mind to notice the tiny hairs on the leaves in **Smells of Spring**, the perfect curve of **Nature's Masterpiece** or the misty **Little Human Touch**. Other examples include the linear and elegant **Sunny Delight**, **A Slender Violet** and **Budding Romance**. To give prominence to the subject, you have to be proficient with precision focus and depth of field. Such insight as demonstrated by a photographer is not unlike the triggers and data acquisition systems of a high energy experiment conceptualized by a physicist.

To get the best result of an exposure, timing is everything. **A Japanese Garden** shot was taken at dusk when the surrounding was quite dim. What I did was to use a tripod and preset a 5-second exposure, and guess what happened? Not only were the traditional Japanese house and bushes visibly featured, note also that the lamps glowed brightly and the goldfish seemed much larger than they actually were, all due to the 5-second exposure. With the help of the correct exposure time, the garden which seemed quiet and desolate at first instant sprang back to life. Such effects can never be achieved with the use of flash. **On a Chilly February Day** also has the same effect. The slight twist is that the former targeted the movement of the fish and water, while the latter aced on the stillness of buildings and architecture. However, if there is insufficient natural light, you will not get the best effect. If the surrounding is pitch dark when you take a picture, by increasing the exposure time will not give you the contrasting effects. Taking pictures of fireworks are a different story. **The Grand Finale** was shot along Lake Geneva on a Swiss National Day. As it was dark when I took the picture, I decided to preset a 30-second exposure and capture two fireworks display using the shutter release. A long exposure time enabled me to capture more of the spectacular light trails of aerial display. And to complete the magnificent picture, I used a wide-angle lens to capture the beautiful waterfront view, and the end result was a picture of joy and jubilance.

When you are taking photographs of a moving animal, longer exposure time may give it a more "dynamic" feel while shorter exposure time may produce a more "static" image. To illustrate this, just take a look at **No**

Turning Back. The photograph was taken on a ship which was traveling at over 30 kilometers per hour, or roughly 10 meters per second. Some birds were flying at the same speed alongside the ship when I took the picture. If I were to photograph the bird from the shore, it would have been impossible to get a sharp image of it even if my shutter speed were set to 1/1000 second (the fastest for ordinary cameras). Yet I managed to get a clear image of the bird on a moving ship with a shutter speed of 1/500 second. The picture was so sharp that you can even see the details of the wings of the bird. Note, too, the surging sea in the background which is aptly described in the caption. But at the end of the day, to get the perfect shot, it will take more than just a pair of steady hands. The telephoto lens is very heavy, and to operate zoom tracking on a wobbly deck is no mean feat. To put more punch into the picture, the position of the bird was tilted towards the top left corner, so as to emphasize the spatial or "forward looking" effect.

Next, I would like to touch on something which marks the major difference between outdoor and indoor photography, i.e. the light sources. Light sources are essential in presenting the theme of a photograph. Roses may wither in just a few days. With the help of a camera, however, I could instantly preserve them in **Eternal Love**. I didn't use fluorescent light or flashlight because the effect would be too stark and cold. I chose tungsten light instead because the orange undertone was very cozy and warm. And to compensate for the dim lighting, I increased the exposure duration. The end result was stunningly romantic. Scenic landscapes are favorite subjects for many. While some may prefer images of choppy waves, my choice picks have always been the serene bays, loving couples, sunset scenes or sunglow. Lighting can be a deciding factor between success or failure for such photographs. Take **Sunset Silhouette** for instance, initially I used auto exposure because I have to capture the scene quickly before dark. But I immediately realized that auto exposure may not work well for an extremely bright object like the sun. So I switched to manual mode, and with a slight under exposure, I successfully produced a totally different look — capturing not just the mesmerizing colors of sunglow but the palm trees' silhouette as well. Other good examples include **The Golden Bay**, **Bon Voyage** and **A Romantic Interlude**. **Switzerland's National Day** is a typical example of night scene images taken with just one single source of artificial light. Glisten in the sunlight, on the other hand, often produces the most striking effect. Just look at **Flame of Paradise**. I used a telephoto lens and manual exposure to shoot the flower. The only lighting was a beam of sunlight which illuminated the pistil. With a blur background, the reflection

was very intense in contrast and looked almost like a hand holding a burning flame.

Now let's consider about angles. Angles are not just important variables in physics, but in photography as well. Conclusive evidence of the existence of the atomic nucleus was obtained from the measurement of the angular distribution of the scattered particles in the famous Rutherford's experiment. In photography, shooting a subject from different angles may result in a world of difference. **Heaven's Nectar** was taken at Niagara Falls. With a wide-angle lens, I took the picture at the bottom of the falls, adopting a slightly tilted upward angle, thus creating a magnificent shot of the thundering water gushing down the abyss. Somehow it reminded one of the Yellow River which seems to flow right from the sky as Li Bai's poem suggested. **Big Splash** was taken at the Niagara fault zone. The impact of the shot is simply breathtaking, and the rainbow is just the icing on the cake.

The Roman Forum is a classic example of a high-angle tilted-down shot. When I went up to the gallery of the church, the view was blocked by windows. I could not find a spot to put my tripod. So to enhance the depth of the field, I set my shutter speed to 1/25 second and captured the panoramic view with the smallest aperture. Images of the crowds on the streets or the tiny little windows as far as a few kilometers away were all well-focused. One other important factor was that the weather was great that day, perfect for taking pictures.

The Mythical World was shot in Atlantic City. As it was an Arabic style architecture, I decided to depict a scene from the Flying Carpet. Using a wide-angle lens, I laid on my back and snapped this colorful and exotic structure against a blue sky backdrop. It looked completely out of this world!

Finally I would like to talk about the **Golden Ratio**. In physics, there are a few intriguing constants. If you look at **Guilin Landscape**, **A Romantic lnterlude** or **City of Chicago**, you would notice that the layouts have approximately adhered to the magic ratio — 0.618. Other examples include **Clear as Day**, **My Fair Lady**, **The Morning After** and **No Turning Back**. Be it a window's dimension or the perfect measurements of a beauty queen, the ratio is always close to 0.618. Why is this number always associated with something aesthetically pleasing? Many scientists have tried to answer that question, but there are no conclusive findings yet. The same goes for some other constants in physics. π for example, is the ratio of the circumference of a circle to its diameter and we may expect that it should only be found in geometric measurements because of its definition. But surprisingly, it is often found in physics calculation as well. Some other constants that show up in

physics are the base of the natural logarithm 2.718, the fine structure constant 1/137, the velocity of light 299792458 meters per second and the absolute zero temperature –273.15°C. You may wonder why these constants do not change with time, and whether there are connections between them or that the new physics is always accompanied by a new constant. Alas it has remained a mystery till this day. Many photographers have unconsciously employed the golden ratio while conceptualizing their photographs. For instance, when you are taking a right-facing profile of a person, you would tend to reserve some space on the right side, and vice versa when you are taking a left-facing profile. But the ratio of object to the edge is always approximately 0.618. A space ratio of 0.618 has proven to be the most pleasing to the eye. The size of this book is no exception. And what would be the best time to shoot sea view images? Well, for me, it has to be in the early morning or just before sunset, when the sun is located around 30 degrees, and interestingly, tan(30) ~0.618. There are countless such examples. Take a look at **Move to the Beat**: the soft lighting and shadows are simply flawless. The more you see, the more you would find 0.618 fascinating. I shall leave it to you to try and resolve this most intriguing mystery.

2. Passion and Patience

What are the most important qualities which a photographer should possess? In my opinion, they are passion and patience. If a person does not feel passionate about Nature, he will not be a sufficiently keen observer of his surroundings to take a good photo. For example, when you pass by a lake with hundreds of lotus flowers, you will miss that unusual one in **Prima Beauty** if you are not observant. Once I was walking through a wheat field, and suddenly I noticed a red poppy flower **The Myth of Narcissus**. Perhaps the seed was dispersed by the wind and it landed there by chance. I was afraid that this unusual scene might not last, so I rushed home for a camera to take this shot. The feeling I had resembled that which a physicist has when he suddenly sees a distinct signature event in the background of an experiment.

It requires a "love at first sight" type of emotion to take good photos of people. At North Sea in Guangxi province, I saw some locals who were selling souvenirs made from shells. A particular girl **A Guangxi Village Girl** caught my attention. That typical nose of the southerners, that thread hanging like a parabola from her bamboo hat, and the parabolic edge of the hat and the parabolic necklace all created an esthetic feeling about curves. To maintain the natural look, I used a telephoto lens and took the picture from a distance

of over ten meters. In the blowing wind, by instinct she raised her hand to hold on to her hat and at that very moment I pressed the shutter. Afterwards, I myself was amazed at the perfect focusing. While the fine details of the inside of the hat are distinctly visible, the chaos at the beach in the background is blurred out. This is indeed an excellent photograph.

Love Me, Love My Cat, **Sweet Tooth**, **Here's Looking at You, Kiddo!**, **Over the Bridge**, **Switzerland's National Day**, **The Amazing Discovery** and **A Day in the Park** are a group of photographs of children. For children's photos, it is better to avoid a formal setting. Indeed, the best photos are shot without their posing. To capture the precious moment, a photographer must have the passion of "love at first sight". Actually, it is rather difficult to take good photos of children. Suppose we use a thermometer to measure the water temperature in a small glass. If the thermometer is too cold, or too hot, or too large, the water temperature will be changed when the thermometer is put into the glass, and we would not get an accurate reading of the original water temperature. This is "interference". Interference should be avoided in taking children's photos. When she had a moustache of ice cream **Sweet Tooth**, I clicked my shutter. When she was running happily, let her run **A Day in the Park**. When she had successfully negotiated the arching bridge **O'er the Bridge**, that expression of hers showing she was pleased with herself was so natural. Such moments like the girl playing hide and seek **Peekaboo!**, the boy deep in thought **The Amazing Discovery**, and the sudden turn of the girl **Here's Looking at You, Kiddo!** were all fleeting ones. The photographer must be nimble and fast to react. Nowadays some professional photographers use motorized cameras and they are also not concerned with the film cost, while some others use digital cameras. They often take seven or eight photos in quick succession, and choose the best one from the set. However, I am an amateur photographer and I must be careful with my film cost. Most of my photos were the result of a first attempt.

Once I was in Texas on business and stayed in a hotel. This hotel had a swimming pool surrounded by tall buildings. It looked quite pretty from my window. However, usually there were many swimmers and that spoiled the atmosphere. For the picture **In the Still of Night**, I waited until midnight when the last person had left the pool area. The water in the pool appeared green under the lights. Most guest rooms had their lights turned off. One indeed had the feeling "in the still of night".

As a photographer, I had rarely obtained a photo of a forest to my satisfaction. That situation remained until I took **Birch Forest**. As an amateur photographer, I have neither an assistant nor sophisticated equipment. Usually

I depend on natural light. It is difficult under such circumstances to get a photo that not only captures the forest, but also shows its layers clearly. Professional photographers, on the other hand, have several assistants to hold reflecting boards or to arrange synchronized flash lights from various directions. Of course I cannot afford such kind of luxury, and I had always regretted for not having taken a satisfactory picture of a forest. Then opportunity came one day. I was driving along an expressway in California when I saw a forest of birch trees. The trunks were tall and erect, the leaves were luxuriant, and the white bark looked like a dress so the trees appeared like a group of innocent and beautiful village girls. It was early in the morning, and the sun shone directly on the trees. Unfortunately, I was on the other side of the highway. After I parked my car at the roadside, I realized that even with a 250mm telephoto lens, I would still not be able to capture the layers of the forest. Thus, risking my life, I gingerly made my way to the highway strip and shot this hard-to-get photo.

In 1989 I was in Japan for a conference. In my spare time I visited the Imperial Palace. I was born during the Sino-Japanese War. My hope for peace motivated me to create a photo that would symbolize eternal peace between China and Japan. I saw a swan in the lake outside the Imperial Palace, and I took the photo **A Moment in Tranquility**. It took me more than one hour to shoot this picture. Of course the swan did not cooperate with me, and the sunlight was also changing all the time. Furthermore, my telephoto lens was not powerful enough so I had to wait for the swan to come closer too. Patience was needed for the appropriate time to come.

Once I attended a meeting in Aspen. In a booklet at the hotel where I was staying, I saw a photo of an abandoned mill among dense woods. I had seen this photo before in quite a few photography books, and was delighted to know that this famous mill was in fact situated in the vicinity. Thus I decided to visit it on a Sunday. Unfortunately, the location is hardly accessible. A proper road ends more than ten miles from this abandoned mill. When I reached that point and was wondering what to do, I met a local resident with an all-terrain jeep. He agreed to take me to a stream a few miles from the mill, since this was as far as a jeep could go. We drove along the so-called road along the edge of a cliff. I am prone to motion sickness, and during this rough ride I felt sick in no time. When I looked down the cliff, I saw the remains of at least two cars at the bottom of the valley and that really scared me. When we finally reached the stream, my gentleman driver told me I had to hike the remaining couple of miles. With my camera in my backpack, I walked for another hour through the valley and the woods before I reached

this famous, wrecked mill. It was built by gold seekers about two hundred years ago. Since the building is surrounded by mountains and dense trees, very little sunlight gets in there. The sky was gloomy when I arrived. I took a few pictures, but I was not satisfied. I was then faced with the dilemma of waiting a little longer or losing my ride back. Just as I was discussing the situation with that gentleman, a ray of sunlight suddenly appeared. I immediately picked up my camera, and shot five or six photographs in quick succession with varying angles and apertures. I spent a whole day just to take this photograph **Lost in the Abyss**, and perhaps it can be said to be my most time-consuming photographic assignment.

Another photograph that tested my patience is **Force of Nature**. I was driving along a California expressway, and saw a group of wind turbines in the distance. The closest I could get would be several miles away from them. With my 250mm telephoto lens, the turbines still looked very small, and there would be a large empty sky in the picture. How could I break the monotony? Wind power is a gift from nature, and the open sky should be able to add some color to the picture. It was late afternoon, and if I want to show the turbines in silhouette, I had to wait for sunset. I pulled my car to the side of the expressway, and even though I was in a rush to get to my destination, I waited patiently for more than half an hour for the sun to drop just below the horizon. The red sky broke the monotony beautifully.

The first time I saw the ocean or sea was in 1964. I was a student at Fudan University, and was sent to Baoshan village for the so-called re-education movement. That place was only about ten miles from the sea coast. I was very anxious to see an open sea, since I had never seen one before. However, during the day we must work with the farmers, and in the evening we must attend meetings with them. So one morning, long before daybreak, I walked to the seaside. That was the first time I saw a sunrise, and appreciated the meaning of "the darkness before dawn". However, I was criticized for my trip by party leaders as a "capitalist lifestyle". I was twenty years old at that time. A little more than ten years ago I went to Texas for a conference. My hotel was right at the seaside. This time I was determined to take a really good photograph of sunrise. I got up around three in the morning when it was still totally dark outside. After a while, the sun began to rise. I was surprised at the speed of its ascent. The seagulls were also early risers, and they were enjoying their morning flight. Before the sun became too bright, I added a filter to my camera lens and took this picture **Fly Me to the Sun** with the smallest aperture of my camera. I presented this photo to a friend of mine as a birthday gift, using sunrise as a symbol that life is full of brightness.

3. Gift of God

It is now possible to manipulate and create photos using computer software. However, the resulting products are not really photography. Genuine photos cannot be created on demand. The photographer has to wait for his luck.

The famous Death Valley is one of the hottest places in the world, and it is also the driest place in North America. Average temperature in the summer exceeds 100 degrees Fahrenheit and annual rainfall is merely 1.96 inches. About ten years ago, we took a family trip to visit this place. As we entered the Death Valley National Park, we were inspired with awe by the desert scene. Suddenly my daughter yelled "Rainbow!" I had heard of a mirage in the desert, but not a rainbow. I looked in the direction of my daughter's finger, lo and behold, there was indeed a small part of a rainbow. And at that very moment, the small section developed into a complete rainbow **A Silver Lining**. Almost by instinct, I grabbed my camera and quickly took several photos from various angles. Within a couple of minutes the rainbow abruptly disappeared. Without this photograph and another one of my daughter in it as a proof, I might have thought it was merely my imagination of seeing a rainbow in a desert. This photo is a gift from God.

The grand canyon is another natural wonder of the world. The view is breathtaking. Although it is usually quite dry in that area, I was lucky to see a rainbow there too **The Mountain Rhythm**. Hiking and mountain climbing are popular with some visitors to the Grand Canyon, and some paths can be very challenging. That day when I passed by a cliff in my car, I saw a dedicated climber doing a solo climb. Since I was in a hurry, I could not wait for him to reach the top. However, after I drove around the circumferential highway, I realized that I was then behind that climber, and at that time he had reached the top. The separation between us in a straight line was about 2 miles. I used a telephoto lens to take a picture of this climber in silhouette **A Humbling Experience**. In comparison with the Grand Canyon, he looked minute. This photograph is also one that cannot be obtained on demand or by design.

One Big Happy Family is a spectacle. Usually a pair of geese will lead a group of goslings in a flotilla formation. Here in this photo we have two pairs of geese forming an escort in the front and also in the rear, and the goslings are lined up so orderly like actors under a director's instruction.

The one photo that perhaps is best described as a gift from God may be **Birds of a Feather Flock Together**. It was taken about twelve years ago, when Chicago had a record low temperature of below minus thirty degrees Celsius.

There are quite a few small rivers and lakes within Fermilab. Their water is used to cool the accelerators in the Laboratory. During cold weather, as soon as the recycled water enters the small lakes, steam is immediately formed. Every winter Canadian geese come here to enjoy the warm water. However, to get a really steaming scene with the geese in the water, three conditions must be met: the accelerator must be operating, the geese must be in the water, and there must be a substantial temperature difference between the water and air. In my seventeen years at Fermilab, I only saw such a combination a few times. Luckily on that day it was so cold that even the exhaled air from my nose became ice at my nostrils. I also remember that the clicking of my shutter made an unusual sound, and I was worried whether the camera was still working properly. From the viewfinder of my camera, all I could see was a blanket of fog. I was also not confident about what exposure should be used. Not until the film had been developed that I discovered the apparent appearance of steaming geese in boiling water. Many of my friends consider this to be my best photo and that is why I have chosen it to appear on the cover design of this book.

Rarely seen events in nature are "gifts from God". So are the rare encounters between people. I have known Nobel Laureate Professor Steinberger since 1979 when he guided me in my physics research, and more than once he mentioned to me his appreciation and respect for Professors C. N. Yang and T. D. Lee. In their younger days, Steinberger and Yang were in fact classmates at the University of Chicago. However, they seldom met afterwards and there was no photo of them together. In 1986 Steinberger was in China promoting the ALEPH collaboration between China and CERN, and his visit had a direct impact on the dispatch of the first international e-mail from China to CERN on August 25, 1986. While Steinberger was in Beijing, I learned from the foreign affairs department of the Chinese Academy of Sciences that Professor Yang was visiting Shanghai at that time. I suddenly got the idea of inviting Professor Yang to come to Beijing to celebrate Professor Steinberger's 65th birthday. This suggestion was supported by the Chinese Academy of Sciences, and accepted by the two great physicists. After a banquet hosted by Professor Zhou Guangzhao, the president of the Academy, I took this picture **Meeting of Great Minds** outside the restaurant.

High energy physics in China has benefited more from the contribution made by Professor T. D. Lee than from anyone else. My own research career in high energy physics can be traced to his 1979 lectures on quantum chromodynamics and quantum statistical mechanics presented in the lecture hall of the Academy. I visited CERN in 1986 and one day Professor Lee invited

me for lunch. I gave him a progress report on the Chinese participation in the ALEPH collaboration, and the successful test run of the first e-mail system. He was very pleased. After lunch, I took the photo **A Gentleman** as a souvenir that I have treasured all my life.

Professors T. D. Lee and C. N. Yang were the first ethnic Chinese to win the Nobel Prize in physics. I had not seen any photograph of them together taken after 1962. During the 1992 April meeting of the American Physical Society in Washington, DC, the Overseas Chinese Physics Association (OCPA) held its annual meeting concurrently. On April 23, the Chair of OCPA invited Professors Lee and Yang to present the Young Physicists Award for outstanding research, and to have a picture taken with the three award winners afterward. Not many people were ready to take pictures since it came as a surprise, but I was. I am honored and deeply grateful that both of them have given me permission to include that photograph **The Making of Great Scientists** in this book. It shows their great concern for the younger generation of physicists.

Ms Ma Xiaohui is one of the very few first-class artists of traditional Chinese music to embark on an international career. During the last decade, she has toured extensively in Europe, Asia and America, in more than thirty countries and regions, to play her erhu (two-stringed "Chinese violin") with leading orchestras in over three hundred concerts. A few months ago, she appeared in a solo concert held in Chicago with great success. I took a picture of her with her erhu at the airport to show her travels around the world. I think the caption **Two-string Universe** is appropriate as there is a string theory in physics to describe the universe.

Professor Ye Minghan is one of the most influential persons in my life. In 2005 China held a symposium in honor of his 80th birthday. Prof. Ye's life is almost a mirror of the history of high energy physics in China. Professor T. D. Lee gave the keynote speech, and I was invited to give a talk at the symposium about the first e-mail system in China. After the meeting, I took **Still at the Frontier at 80**.

Sometimes a scene may be common, but a photo **A Historical Relic** can have a historical value if the scene has changed. Although insect-sized birds are not a rare sight in certain places, they are so alert that it is difficult to find them stationary for any length of time. The difficulty is compounded for me since I do not have a very powerful telephoto lens. **Tweety Bird** is an exceptionally precious photo.

Once I was walking along a lake, and noticed that someone had achieved a remarkable balancing act with stones **A Wonderful Feat**. The topmost

large stone sitting on a fist-sized small one was an impressive sight. All these photographs were gifts from God, given to me while I was just wandering around. Photographs like **Lost in Reflection**, **What a Splitting Image**, and **Shangri-la** may be quite common. However, the slightest wind will destroy a perfect reflection. The reflection in these three photos is nearly perfect, and one can almost view the pictures upside down. I sometimes have the wishful thinking that how nice it would be if I can have similar luck in my research experiments.

Concluding Remarks

When I first picked up a camera fifty years ago, I could never have imagined that fifty years later I would be publishing a collection of my photographs in a book. My camera, a first generation "Seagull" brand made in China, has become an antique piece. After the publication of this book, I shall bid farewell to the era of film photography, and move on to the digital one.

All the photos in this collection were taken with an ordinary camera using films. Recently I scanned the photos to convert them to a digitized form. In fact, the color of the photos obtained from scanning is inferior to that of the original copies, especially for those originals over twenty years old. Furthermore, since I am an amateur without sophisticated equipment, some of my work may appear unrefined.

In order to keep this book to a reasonable size, I have omitted the stories behind some of the photographs. If the reader finds something nice in this book, then as the great Indian poet Tagore said "I am not the best, the best has chosen me". I differ from other photographers in that I always regard photography as an optical experiment: first there must be a theme or central subject, then there is the technical procedure, and finally the photo is the report of my experiment.

Of all my achievements, two will always remain close to my heart: being the first person to send an e-mail out of China, and producing this collection of photos. The first e-mail from China was sent out exactly two decades ago, marking China's first step towards the Information Age. And look how far we have come! The internet has indeed transformed the ways we communicate with the world. Photography, on the other hand, is an amazing art form not unlike music — it is a universal language that transcends all human boundaries.

I am a physicist, and photography is merely my hobby. I have very simple equipment, and the subjects or events I captured on film are just what lay

people like to see. I hope that after you have finished reading this article about the stories behind the photos, you will conclude by saying "if you can do it, so can I!"


Dedication

This page intentionally left blank

To my late father Wu Benhao, my mother Luo Xi

To my wife Liu Li

To my daughters Wu Yuanxing (Esther) and Wu Yin (Yvonne)

To my sisters Wu Fumin and Wu Xiaomin, brothers Wu Jimin, Wu Xinmin and Wu Minmin

To my dearest friend Professor K. K. Phua, Professor Wu Saulan and to all human beings who rejoice in the world of Sciences, Art and Living

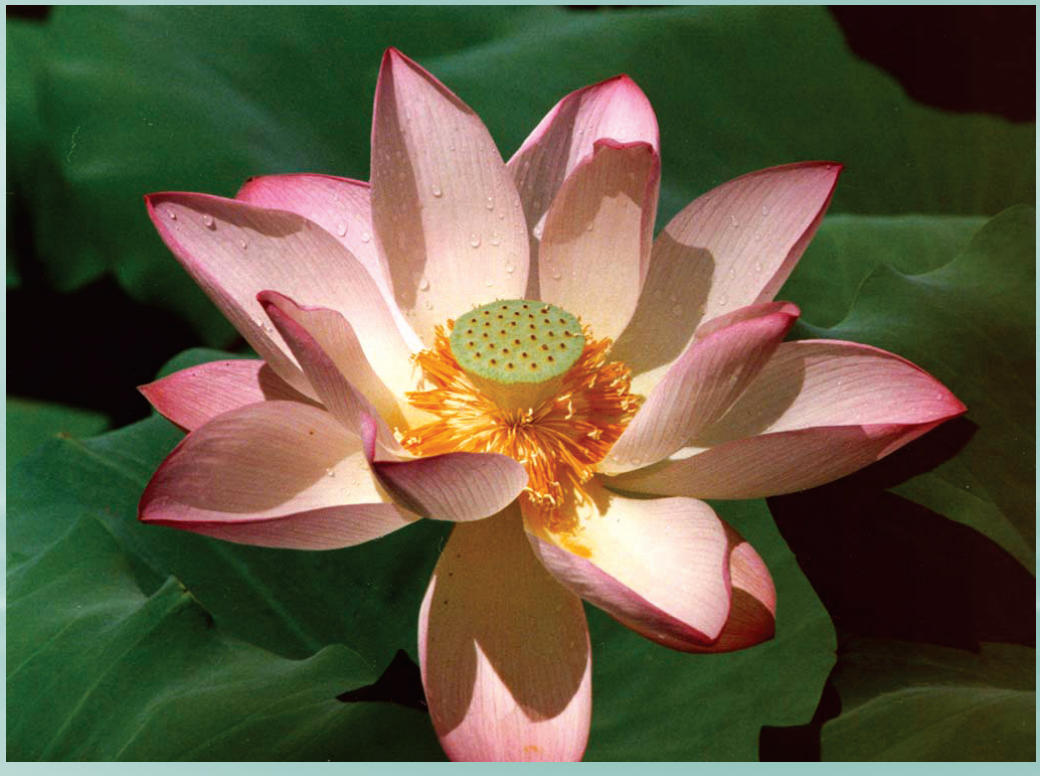
This page intentionally left blank


Flowers

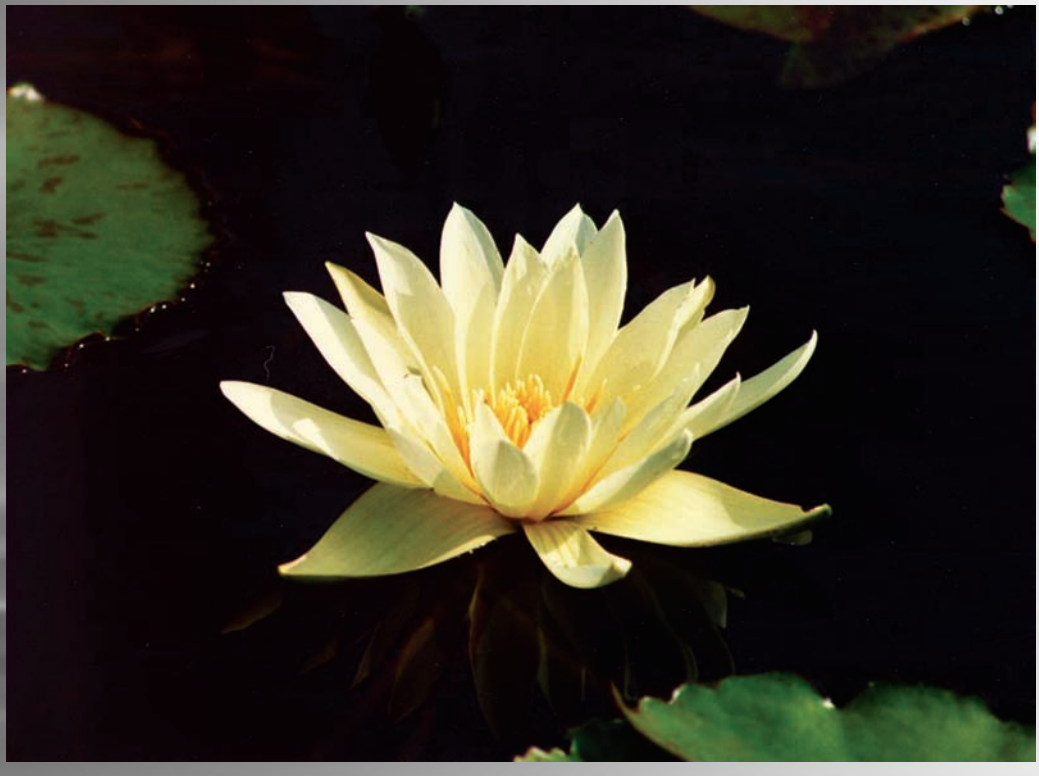
This page intentionally left blank

天堂烈火　Flame of Paradise

紫花亭立　A Slender Violet



青春永驻　Prima Beauty



一尘不染　Chaste

一支独秀　The One and Only

如锦如绣　My Fair Lady

玉撒浮萍　Spreading the Joy

几何大师　A Nature's Masterpiece

永恒爱情　Eternal Love

刺球奇艳　A Thorny Encounter

阳光滋润　Sunny Delight

壳层模型　Layer to Perfection

含苞待放　Budding Romance

微型小鸟　Tweety Bird

仙球王国　A Pebble Nursery

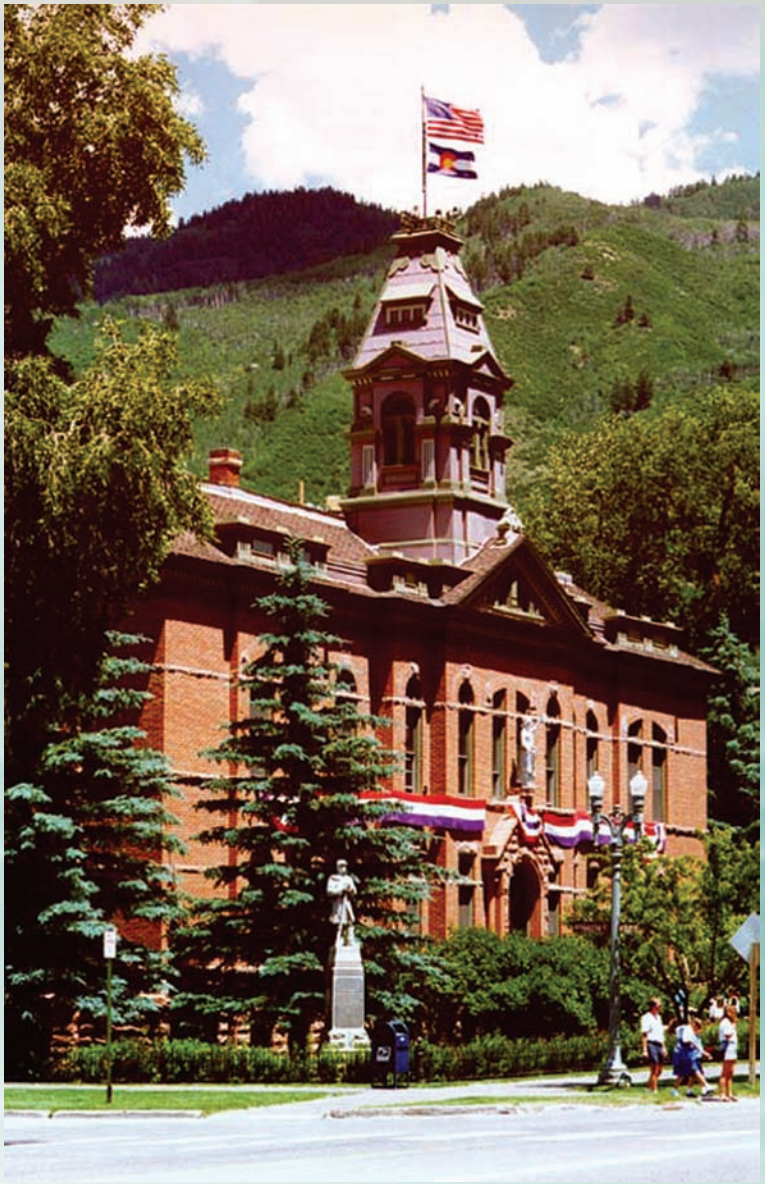
辛勤劳动　Bees at Work

嫩叶初生　Smells of Spring

郁金王国　Tulips Rule

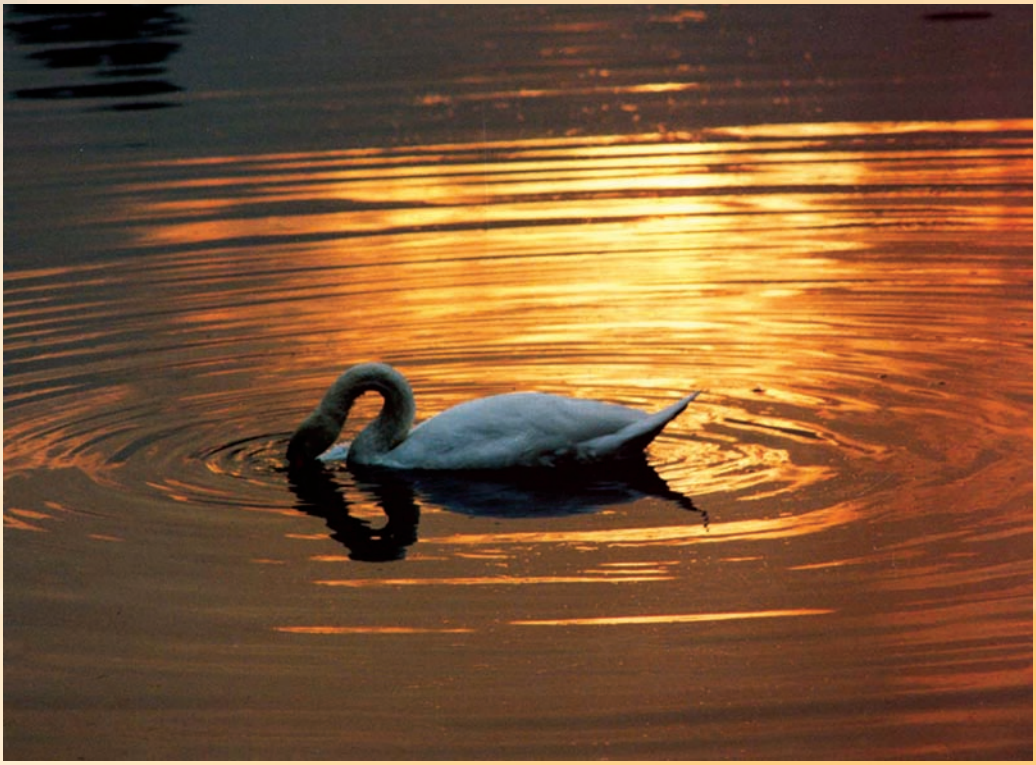

Landscape

This page intentionally left blank



山城古楼　The Aged Tower

喜气洋洋　The Grand Finale



悠然自得　A Moment in Tranquility

密林深处　Lost in the Abyss

白桦丛林　Birch Forest

日本庭园　A Japanese Garden

夕阳西下　Sunset Silhouette

百鸟朝阳　Fly Me to the Sun

喜遇双蛋　Double Happiness

冰冻仕女　Icy Lady

亮如明镜　Clear as Day

巍然屹立　A Stately Presence

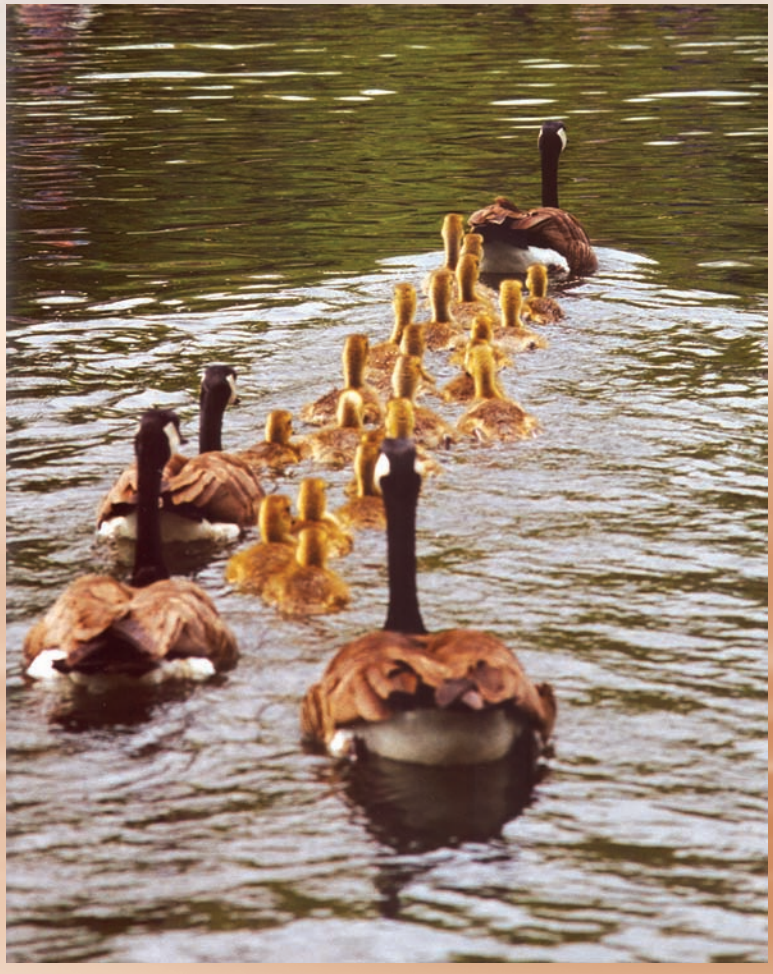
群山深处　The Hills Are Alive

夜深人静　In the Still of Night

双塔女神　Twin Towers and the Statue of Liberty

山舞银蛇　The Mountain Rhythm

顿失滔滔　Big Splash



合家团圆　One Big Happy Family

荒漠彩虹　A Silver Lining

罗马广场　The Roman Forum

水从天降　Heaven's Nectar

风力发电　Force of Nature

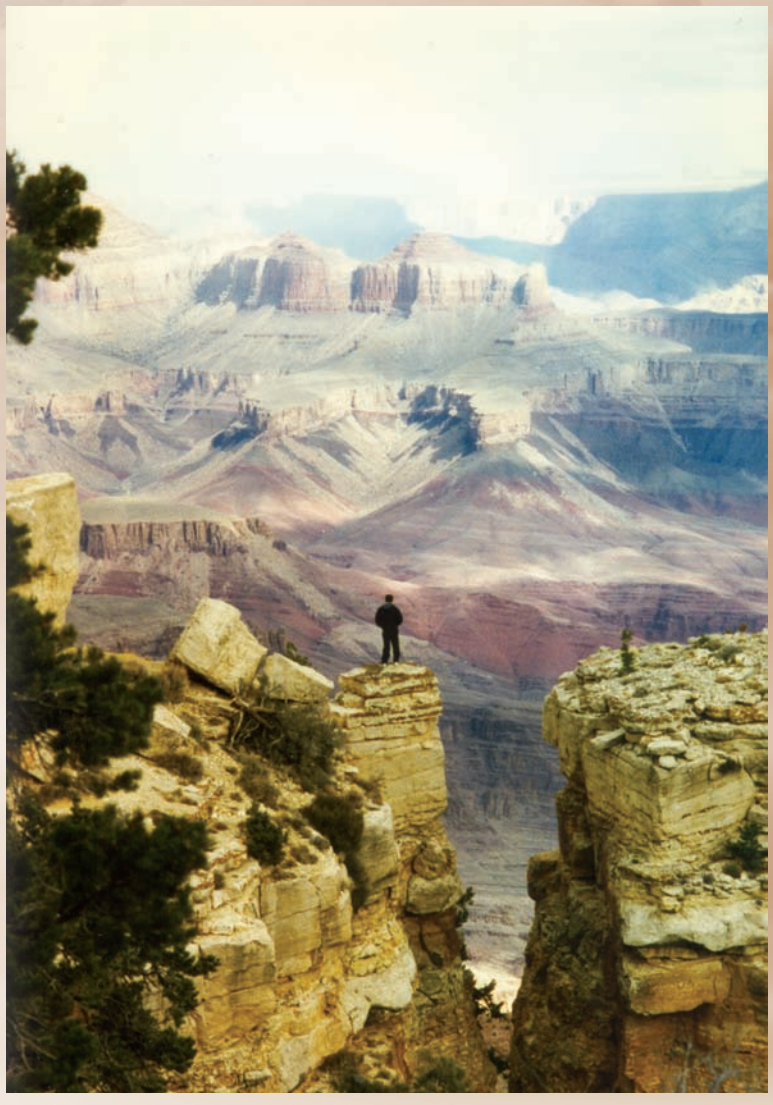
早春二月　On a Chilly February Day

世外桃源　Xanadu

时隐时现　Hide and Seek

历史遗迹　A Historical Relic

神话世界　The Mythical World



人生渺小　A Humbling Experience

金色海湾　The Golden Bay

孤舟远航　Bon Voyage

万家灯火　City Lights, Starry Night

晨曦沉睡　The Morning After

诗情画意　A Romantic Interlude

芝城剪影　City of Chicago

形影不离　My Great Companions

桂林山水　Guilin Landscape

People

This page intentionally left blank

瑞士国庆　Switzerland's National Day

广西姑娘　A Guangxi Village Girl

我爱我猫　Love Me, Love My Cat

慈祥大师　A Gentleman

老少同乐　Age Is No Barrier to Having Fun

大师重逢　Meeting of Great Minds

幸福童年　A Day in the Park

笑容可掬　Sweet Tooth

聚精会神　Here's Looking at You, Kiddo!

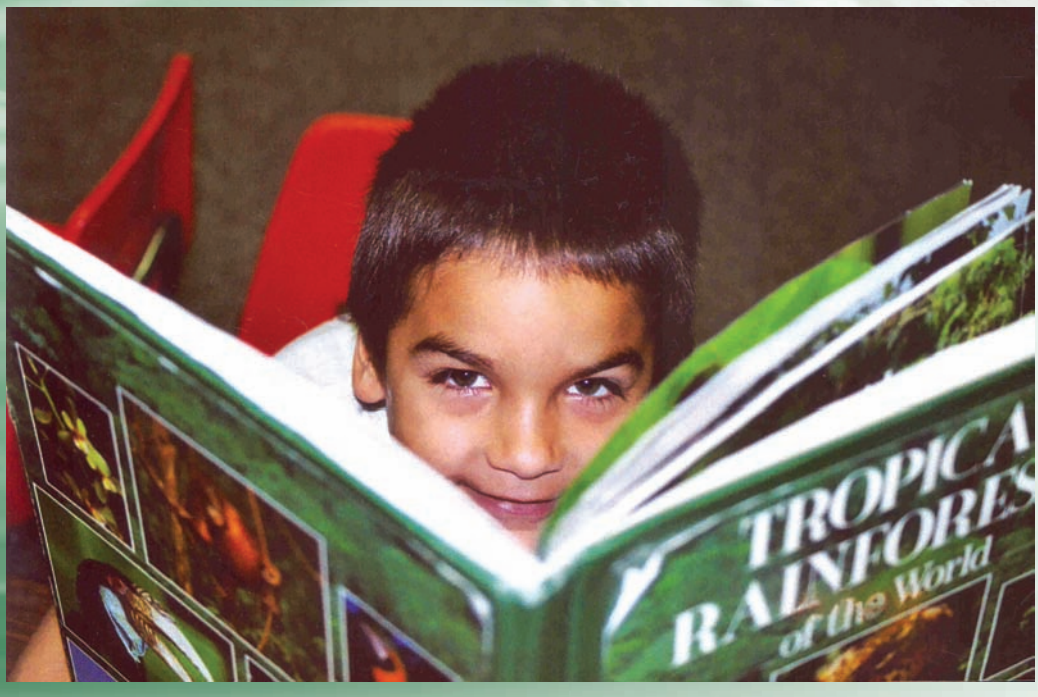
我过桥了　O'er the Bridge

久别重逢　Long Time No See

初学奔跑　A Runner in the Making

我在这儿　Peekaboo!

肢残心明 A Great Inspiration to Mankind



异想天开　The Amazing Discovery

八十大寿　Still at the Frontier at 80

面向未来　The Making of Great Scientists

深思熟虑　A Great Thinker of Our Time

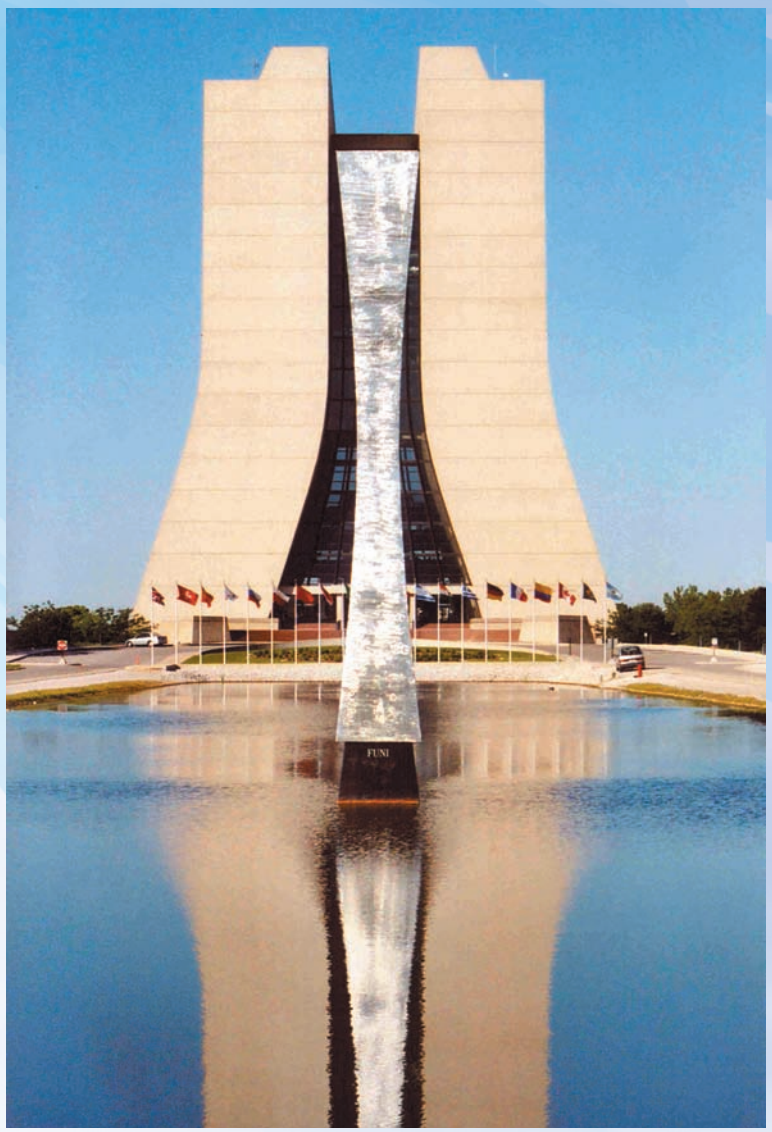
满怀欣喜　An Ecstatic Moment

宇宙之女　Two-string Universe


Beauty of Physics

This page intentionally left blank

格点规范　Latticework

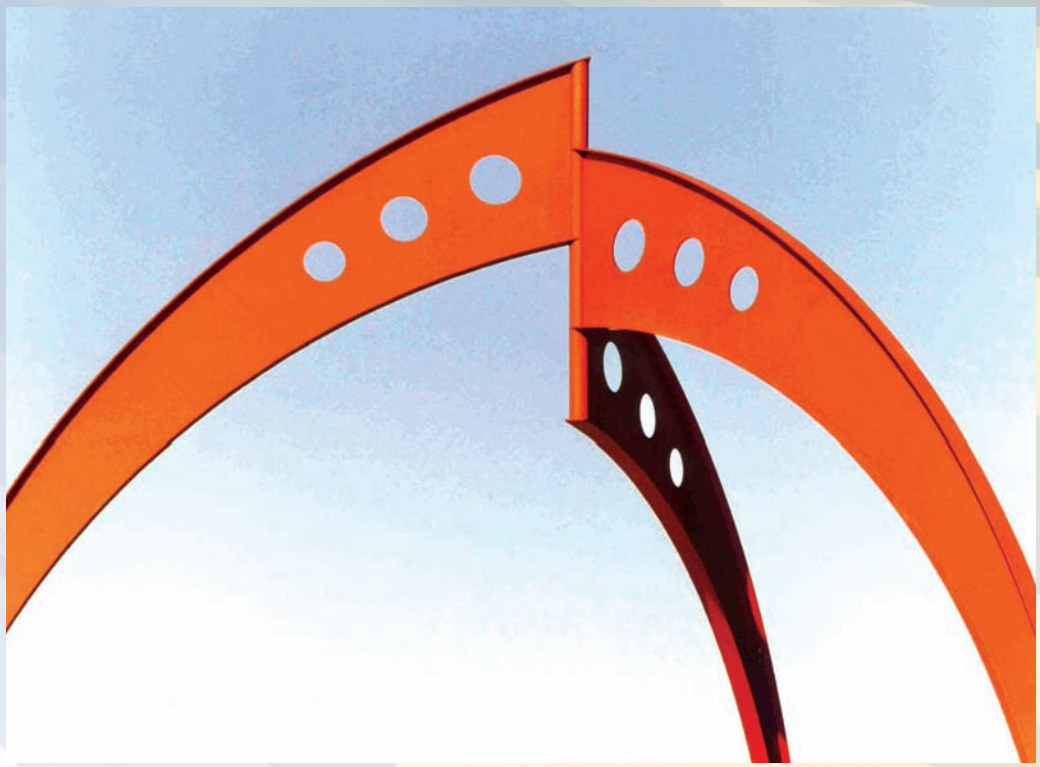


多重对称　Multi-symmetry

直线螺旋　Vertical Weave

立体曲面　3-D Toroidal

多维空间　Multidimensional Space



对称奇异　Incredible Symmetry

乱中有序　Orderly Chaos

庞贝遗址　Pompeii — The Forgotten City

群鹅嬉温　Birds of a Feather Flock Together

天然杂技　A Wonderful Feat

人造仙景　A Little Human Touch

勇往直前　No Turning Back

美错地方　The Myth of Narcissus

对称破缺　Lost in Reflection

无穷无尽　Blooming into Infinity

阴阳八卦　The Eight Diagrams

直冲云霄　The Sky Is the Limit

无限张力　Stretching Beyond

翩翩起舞　Move to the Beat

序中有乱　Outwardly Calm

千年奇迹　A Millennium's Creation

抽象世界　The Impressionist

雪山明镜　What a Splitting Image!

香格里拉　Shangri-la

沉睡初醒　All Bright and Early