SELECTED WORKS OF QIAN SANQIANG

钱三强论文选集

《钱三强论文选集》编辑委员会 编

科学出版社

Responsible Editor: Yan Deping

Published by Science Press
16 Donghuangchenggen North Street
Beijing 100717, China

First Published 1993
ISBN 7-03-003801-0/O • 667
Printed in Beijing

主　编： 周光召

副主编： 钱皋韵

编　委：（以姓氏笔划为序）

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1980年12月摄

1946年春摄于巴黎

1948年春与约里奥-居里夫妇合影

1958年 8 月22日，周恩来总理和陈毅、贺龙副总理陪同西哈努克亲王参观中国科学院原子能研究所（左起第一人为钱三强）

1973年2月钱三强和何泽慧在共同讨论和撰写《原子能发现史话》一文

1978年6月16日钱三强在总主任J.B.阿达姆斯(Adams)
陪同下参观欧洲核子研究中心(CERN)

序　言

今年10月16日，是杰出的科学家、我国原子能科学事业的创始人、中国科学院学部委员钱三强先生诞辰80周年。一年多以前，作为他的学生，我们本准备届时庆贺一下的，没想到他在去年6月28日突然病逝，现在出版这本科学论文集，是一个纪念，也可以寄托大家的哀思。

1913年，钱先生出身在一个进步文化人家庭。父亲钱玄同，是五四新文化运动的倡导者之一。钱先生自幼就受到良好的教育和爱国进步思想的熏陶。1936年他从清华大学物理系毕业后，到北平研究院物理研究所工作。本书第一篇文章“铷分子的带光谱与解离能”，就是他在所长严济慈先生指导与合作下完成的第一个实验研究工作。

1937年夏，钱先生考取了公费留法，到巴黎镭学研究所，在弗莱德里克·约里奥和依莱娜·居里两位先生指导下，从事原子核物理的研究。在法国经历了第二次世界大战，直到1948年回国。这11年，是钱先生一生中个人研究成果最丰硕的年代，收入本书的论文，绝大多数属于这个时期。从研究内容等方面看，还可以第二次大战结束的1945年为界，划分成前8年和后3年两个阶段。

从前8年的近30篇文章，本书读者至少能得到一个深刻的印象，那就是钱先生工作的勤奋。在不算太长的时间内，做了那么多的实验，涉及到那么多方面的原子核物理问题，而且大多做出了第一流的成绩。例如，1939年“铀和钍产生的稀土放射性同位素辐射的比较”这一工作，是与依莱娜·居里合作的。他们的实验证明，铀和钍受中子照射后产生的镧β放射性是相同的。也就是说，不同的裂变方式能得到同样的产物，这对于那时刚提出不久的裂变概念，是一个很好的支持。又如，在天然放射性的低能γ射线方面，他们用巧妙而简明的方法，解出了复杂的谱线，定出能量和绝对强度，弄清了不少问题，其中，“Ac和AcK的γ射线”一文更为重要。因为AcK就是由这篇文章的另一作者发现的新元素钫的同位素Fr-223。又如，“中速和低速电子的射程-能量关系”仔细研究了电子径迹末端的弯曲，给出了50 keV以下的电子能量-射程关系，既对实验工作者有参考价值，也是对Bethe理论的很好检验。还有，像α能谱的精细结构，核能级，内转换，放射性物质的反冲扩散，等等，这些当年核物理领域的前沿问题，钱先生都作了研究，并都有自己的贡献。

应该指出，以上研究工作，是在极为困难的情况下完成的，当钱先生离开北京时，抗日战争就在国内展开了。不久，父亲钱玄同由于忧愤过度而逝世。再后，第二次世界大战全面爆发，巴黎沦为德占区，钱先生长期处于报国无门、有家不能归的状况，作为一个热血青年，他的心境，是可以想象的。可是就是这样，在实验室里，钱先生依然无休止地勤奋工作，工作在世界物理科学的最前沿。甚至1942年，欲寻求回国，但因战争受

阻，滞留在里昂，临时在里昂大学任教，即或这样，他在科研上依然没有停步，本论文集中就有两项工作是在那里做的。其中之一“用照像乳胶记录带电粒子”，应该说是早期探索研制原子核乳胶的较好工作之一，没过几年，这一新型探测器就得到了广泛的应用。

第二次世界大战结束后，何泽慧先生从德国到达巴黎，从此两位先生在一起并肩工作。钱先生后 3 年的科学研究也进入了一个更高的阶段，这就是重原子核三分裂和四分裂的发现。关于这件事，本书有十多篇论文，其中最重要的两篇，有钱先生自己的汉语译文。前几年钱先生还专门写过一本科普小册子，读者可以直接从原文了解详细情况。我在这里只强调以下几点：(1)当年，与两位先生的发现几乎同时，英、美、加三国也有人看到铀核的三分裂径迹，但只作了简单的观察，工作没有深入，轻易地把这一现象放过去了。还有人(如英国费瑟，他是卢瑟福的学生)认为只是 α 粒子，其机制是二次发射，不是三分裂。而钱先生他们却抓住不放，把实验深入下去，尽可能把问题彻底弄清。在大量细致的实验测量基础上，进行分析计算，得出质量、动能和角分布等数据，综合起来，结合理论考虑，令人信服地证实了三分裂新现象的存在。(2)有一些问题限于实验条件，是当年不可能解决的，但钱先生和何先生作了预言，这些预言，经过几十年，主要是 60—70 年代用新的实验手段半导体探测器完成的大批工作都得到了证实。(3)三分裂的发现，不仅深化了人们对裂变反应的认识，而且由于它是研究断裂点特性的一种有效的、直接的探针，在裂变机理研究中有独特作用，所以，几十年来不断有人进行实验和理论的探讨，迄今为止，它仍然是核裂变领域中的一个研究对象。

11 年的成就是辉煌的。可以设想，如果在实验室里继续潜心研究下去，钱先生在后半生肯定还会有很多的成果，还会有重要的发现。要是那样的话，现在这本论文集，也就会厚得多，但是，钱先生却选择了另外一条道路。

两位先生决心为祖国的科学事业而献身，1948 年夏他俩放弃国外优越的工作条件和优厚的待遇，毅然回国。新中国成立后，为了振兴中华，钱先生服从组织安排，牺牲了个人在科学上要有更多更高发现的追求，全身心地投入科学组织管理工作。

他从一开始就参加中国科学院的组建工作，并长期参与领导，为科学院的发展、各个不同时期重大问题的决策、为国家重大攻关任务和国防建设组织和调动院的力量，还有，在加强学术领导，创建和发展学部工作，开展国际交流等许多方面，钱先生做了大量、卓有成效的工作，他辛勤操劳了几十年，真是呕心沥血。还应该指出，钱先生在科学界(包括国际科学界)做了许多团结人的工作，起了非常好的作用。

钱先生在我国原子能事业方面 的功绩，是众所共知的。从近代物理研究所时期，钱先生就求贤若渴，广揽人才，知人善任，一心要让“原子能科学在中国生根”，为此，他筚路蓝缕，带领大家一步一步艰辛创业。后来，长期由他担任所长的这个研究所，终于逐渐发展成为综合性的核科学技术研究基地，在我国原子能事业发展过程中，在技术基础与人才培养两个方面，起了极为重要的作用。

在我国核工业建设全面展开之后，调兵遣将，规划安排，钱先生挑起的担子就更

重了。他的精湛的科学知识和远见卓识，他的杰出的组织工作才能，在事业中发挥了"不可替代"的作用。这里特别要提到的，就是他对青年的关心与信任，在对青年科技工作者教育与培养方面，他在强调钻研业务的同时，特别重视思想品德要求，他一再告诫大家不能追逐名利，要服从国家需要。正是在一代像他那样的老科学家的带领和影响下，我国的原子能科技工作者不怕艰苦，默默拼博，终于做出了使全体中国人民扬眉吐气的光辉业绩。

钱先生为人坦诚、刚直，不迎合潮流，对于不尊重客观事实的情况，大胆直言，从不苟同，即使个人遇到压力。因而在那不正常的岁月里，他曾不止一次受到不公正对待，然而他对真理坚信不移，对事业执着追求，从不懈怠。粉碎"四人帮"后，尽管他身体不太好，仍然不辞辛苦，忘我工作，活跃在科学舞台上。如重建科学院学部，为国际学术交流开拓新路，推动科技改革和新的研究领域的发展，对国家重大科技、经济、社会问题组织讨论，提出建议，等等。一直工作到他最后的那些日子里。

彭桓武先生在悼念钱先生时写了这样的诗句："人民站起新时代，科学还需指点才。"钱三强先生正是这样一位掌握全局、运筹帷幄的指点之才，他无愧于这个时代。在科学界，他是这个时代的代表，同时，他又是时代的楷模。这并不只是由于他在原子核物理上的重要发现和做出了饮誉海内外的光辉业绩，而且还因为，他全部科学生涯中贯穿着的深厚的爱国主义和崇高品格。熟悉钱先生的人，不会忘记他那宽阔的胸怀，勇挑重担的气魄，杰出的组织才能，甘为人梯的精神，谦逊朴实的作风，以及只求奉献不求索取的高风亮节。在钱先生身上，科学和道德达到了高度的统一。正是因为这样，钱三强先生才受到广大青年学生的仰慕，科学工作者的爱戴和全国人民的普遍尊敬。

周光召

1993 年 2 月

Preface

October 16, 1993 is the 80th anniversary of the birth of Prof. Qian Sanqiang (Tsien San-Tsiang), outstanding scientist, founder of China's atomic energy science and member of the Chinese Academy of Sciences. More than a year ago, as his students, we intended to hold a grand celebration on the occasion of his 80th birthday. Unfortunetely, he died on June 28 last year at the age of 79. As a token of our deep grief, we now publish the selection of his scientific treatises in memory of him.

Mr. Qian was born into a progressive family of culture in 1913. His father, Mr. Qian Xuantong, was one of the pioneers of the May 4th new cultural movement. Exposed to an atmosphere of patriotism and progressive thoughts, he was well educated in his youth. After his graduation from the Department of Physics of Tsinghua University in 1936, he worked in the Institute of Physics, National Academy of Peiping. The first article in this selection entitled "Band Spectra and Energy of Dissociation of the Rubidium Molecule" describes his first research work performed under the guidance of and in collaboration with Prof. Yan Jici (Ny Tsi-Ze), director of the Institute.

Mr. Qian was sent to study in France in the Summer of 1937 at public expense. He studied nuclear physics under Profs. Frederic Joliot and Irene Joliot-Curie in the Institute of the Radium of Paris. He stayed in France through World War II until 1948 when he returned home. The 11 years in France witnessed the greatest achievement in his scientific research, for most of the treatises collected here were written in that period. With regard to his research, the 11 years can be divided into two phases, the first 8 and the last 3 with 1945, when World War II ended, as the demarcation line.

The readers will no doubt be deeply impressed by Mr. Qian's diligence in the first 8 years when he wrote as many as 30 articles and did a large number of experiments on various aspects of nuclear physics, most of which were crowned with brilliant success. For example, "Comparison of the Radiation of Rare Earth Radioactive Isotopes Produced by Uranium and Thorium" was based on the experiment performed in collaboration with Irene Joliot-Curie in 1939. The experimental results proved that β radioactivities of the lanthanum induced by neutron irradiation of uranium and thorium are identical. This meant that different modes of fission could yield the same fission product, thus giving a strong support to the newly developed theory of nuclear fission. The study of low energy γ rays of the natural radioactivity can be taken as another example. He adopted a very clever and simple method to analyse the compli-

cated energy spectra and to determine the energy and absolute intensity of γ rays so that many problems became clarified. Among the articles, the one entitled "γ rays of Actinium and Actinium K" is especially important because actinium K is the isotope ^{223}Fr of the new element francium discovered by the co-author of the article. "The Energy Range Relation of Low and Medium Energy Electrons" shows how carefully he studied the end bending of electron tracks and obtained the energy-range relation of electrons below 50 keV. The results are valuable to experimentalists as well as a good test of the Bethe theory. Besides, such frontiers of nuclear physics at the time as the fine structure of α particle energy spectra, nuclear energy level, internal conversion and recoil diffusion of radioactive materials were all among the subjects he studied and made contributions.

What is especially commendable is the way he got all these done in spite of very difficult conditions. When he left Beijing (Peiping, Peking) , flame of the War of Resistance against Japan was spread out in China. Soon after, his father Qian Xuantong died of excessive worry and indignation. Later, World War II went on in full swing and Paris became a German occupied area. As an ardent patriot how he felt was imaginable when he was long stranded abroad yearning in vain to return home and offer his service to the motherland. Even in such a situation, he worked endlessly and assiduously in the laboratory and studied the frontiers of physics science. He tried to return to China in 1942, but was held on the way because of the war. He had to stay in Lyon and took a temporary job of teaching in Lyon University. Even then he did not stop his scientific research, which produced two articles in this selection. One of them is "Detection of Charged Particles by the Photographic Emulsion", a successful early exploration of the manufacture of nuclear emulsions. Before long, the new type detector of nuclear emulsion received a wide range of applications.

Soon after the end of World War II, Prof. He Zehui (Ho Zah-Wei) arrived in Paris from Germany. From then on, the two of them worked shoulder to shoulder. Their first cooperation resulted in the discovery of the ternary and quaternary fissions of heavy nuclei, which marked a more advanced stage in his scientific research during the last 3 years in France. More than 10 articles in this selection are devoted to this discovery. Among them the two most important articles were translated into Chinese by Mr. Qian himself. He also wrote a popular science book on the discovery of the ternary and quaternary fissions of heavy nuclei several years ago. As the details can be found in relevant articles, I only want to emphasize the following points. (1) Though British, American and Canadian scientists also observed the tracks of the ternary fission of uranium almost at the same time, they did not carry on a penetrating study on the new phenomenon and inattentively let it slip. Some other people, e. g. Feather of England, a student of the world-famous scientist Rutherford, thought that the observed tracks were caused by α particles and originated from the secondary emission rather

than the ternary fission. In contrast, Profs. Qian and He never stopped short of a complete awareness of the observed phenomenon and did a thoroughgoing study on it. Based on a great amount of their carefully performed experimental measurements, they made numerous calculations and analyses so as to obtain the useful data of the mass, kinetic energy , angular distribution, etc. Summing up all their findings in association with theoretical considerations, they convincingly proved the existence of the ternary fission—a new discovery. (2) They could not solve certain problems due to limited experimental conditions, but made predictions which were verified later, mainly in the 1960s and 1970s, by means of semiconductor detectors. (3) The discovery of the ternary fission greatly deepened the understanding of the nuclear fission reaction. It has proved particularly useful in the study of the nuclear fission mechanism by serving as a direct and effective probe to investigate characteristics of the scission point. Therefore, the ternary fission has been studied experimentally and theoretically for dozens of years. Till now it remains an interesting topic in the study of nuclear fission.

The 11 years were years of brilliant achievements. How much more would he have achieved if he had carried on his research in the laboratory for the rest of his life! Definitely there would have been much more scientific results of great importance produced by him and this selection of treatises would be much more plentiful. But as it was he had to make another choice and embark on another road in life.

They two were determined to dedicate themselves to the motherland's science. They abandoned excellent working conditions and liberal offers abroad and resolutely decided to return home in the summer of 1948. After the founding of New China, for the overall interest of rejuvenating China, Mr. Qian accepted the state assignment and wholeheartedly devoted himself to the scientific managerial work at the expense of his promissing scientific career.

Mr. Qian took part in establishing the Chinese Academy of Sciences from the very beginning and was a member of its leadership for a long time. He devoted himself to its development, participating in policy-making on important issues at different periods and organizing and mobilizing competent persons of the Academy to join and help fulfil important national key tasks and build up national defence. In addition, he contributed a lot to the work of the academic leadership, the establishment of the Academic Council of the Chinese Academy of Sciences and the development and promotion of international exchanges. He worked painstakingly and devotedly for decades. Moreover, he made great efforts to unite people in the science circles both at home and abroad and achieved good results.

His great merit is well known in China's atomic energy science. When the Institute of Modern Physics was established, Mr. Qian made up his mind to let the atomic energy science take root in China . For this purpose, he went to great lengths looking for talent far and wide, invited as many capable men as possible and assigned them jobs commensurate with

their ability. It was he who endured great hardships in pioneering work and led his men steadily forward with painstaking efforts. Afterwards, the Institute, of which he was director for a long time, gradually developed into a comprehensive research base of nuclear science and technology in China. It has played a key role both in developing China's atomic energy science and in training competent persons.

As China's nuclear industry went full steam ahead, Mr. Qian was entrusted with ever-increasing responsibility, making plans and arrangements with proper deployment of forces. His rich knowledge of science, his far-sightedness and his skill in organizational work made him indispensable—nobody could take his place. Among others, special mention should be made of his role in educating young scientists. He not only showed concern about them but reposed confidence in them. While putting emphasis on professional proficiency, he attached great importance to moral integrity, often exhorting them to comply with the state needs and not to seek personal fame and gain. China's atomic energy scientists guided by him and others of the older generation feared no hardships, worked silently with all their might and eventually made brilliant contributions which have added glory and great credit to the Chinese people.

A straightforward and upright man, Mr. Qian dared to speak his mind when confronted with distortions of facts, nor did he blindly follow the trend even if it meant a heavy pressure to bear. It goes without saying that a man like him would have been subjected to unjust treatments more than once during the abnormal years in our history. However, his faith in the truth was never shaken, nor his scientific pursuit slackened. After the smashing of the Gang of Four, although in poor health, he was still active on the scene of science, making nothing of hardships, working selflessly for rebuilding the Academic Council of the Chinese Academy of Sciences, opening new channels for international academic exchanges, pushing the reform of science and technology and exploring new avenues of scientific research as well as making proposals through discussions on issues vital to science and technology, economy and society. He kept working until his last days.

As a memorial poem by Mr. Peng Huanwu puts it: "In a new era when the people are masters, it calls for a master of science to give orders." Mr. Qian was precisely such a master of science who could, in view of the overall situation, devise strategies and issue orders, who was equal to the tremendous task set to him by the epoch, representing the epoch in the science circles and serving as a good example for others to follow. This is not only because of his important discovery in nuclear physics and his outstanding achievements which earned him great fame both at home and abroad, but, especially, because of his profound patriotism and lofty personality underlying his scientific career. People who know him well will never forget his broad-mindedness, his courage to shoulder heavy burdens, his outstanding organizing ability, his willingness to serve as a ladder for juniors to climb to success, his modesty and plain-living

and his utter devotion and selflessness, which are all valuable legacy to posterity. Mr. Qian Sanqiang was such a shining example combining science and virtue harmoniously that he has always been looked up to by young students, loved and esteemed by scientific workers and highly respected by the people throughout the country.

Zhou Guangzhao
February 1993

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