张文裕论文选集

SELECTED WORKS OF CHANG WEN YU

科学出版社

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《张文裕论文选集》编辑委员会　编

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序 言

张文裕教授是我国著名的核物理学家.宇宙线及高能实验物理的奠基人之一。他是福建惠安县人,1910 年 1 月出生,1931 年毕业于北平燕京大学物理系, 1934 年考取英庚款公费赴英留学,1938 年在英国剑桥大学取得博士学位。1943 年再度出国,到美国普林斯顿大学及普度大学工作,1956 年回国。

张文裕教授从研究生学习期间就开始进行核物理研究工作。三十年代至四十年代,他在英国和美国进行关于核衰变和核反应的研究,特别对天然放射性同位素的 α 能谱进行精密的测量。四十年代后期,他在美国用云室进行宇宙线研究,进一步确定 μ 子和原子核没有强作用,并在 μ 子吸收的研究中确证了 μ 介原子的存在,从而开创了关于 μ 介原子的研究工作;导致利用重氢的 μ 介原子产生轻核反应的研究,以探索释放氢核能的可能途径。

抗日战争期间,他在国内极其困难的情况下,自己动手,积极创造条件,开展宇宙线研究工作。1956 年回国後,又积极促进云南落雪山宇宙线实验站的扩建,与肖健先生共同领导建造了当时世界上最大的大云室组,培养了一代宇宙线研究者,作出了有意义的物理工作。

六十年代初,张文裕教授领导中国科学工作者在苏联杜布纳联合核子所利用加速器进行高能物理实验工作。他把当时已知的重子共振态归纳成核子和超子的激发态,提出了一个重子能级和跃迁图。并根据这个想法对 Λ° 超子和核子散射现象进行了研究。

张文裕教授十分关心我国的高能物理事业,在他以及其他一些同事的倡议下,经国务院批准,1973 年成立了中国科学院高能物理研究所,开展了高能加速器和高能物理的研究工作。

张文裕教授一贯重视理论与实验相结合,强调发展实验科学,认为实验是理论的源泉和科学的基础。他多年来孜孜以求的,是要建立我国自己的实验基地,培养并形成我国自己的高能物理实验队伍。他身体力行,筹划并推动这一目标的实现。我国正在建造北京正负电子对撞机工程,张先生多年奋斗的目标即将实现。

张文裕教授十分重视科研与教育的结合,他先后在四川大学、西南联大、美国普林斯顿大学、普度大学,及中国科技大学任教,为科大近代物理系的成长作出了贡献。他培养的许多学生已经成为知名的物理学家。

这本选集收集了他各个时期的研究工作成果,以及他对实验科学重要性的论述。

我和他相交五十多年,深信他这本选集的出版,将对年轻一代有所启迪。他们可以从中看到一位老一辈科学家走过的道路,不仅从他的学问和贡献,也从他的学风、事业心和历史责任感得到教益。

赵忠尧

1988 年 6 月 15 日

PREFACE

Professor Zhang Wen–Yu (W.Y.Chang) is a famous nuclear physicist and one of the founders of the cosmic rays and experimental high energy physics in China. He was born in Hui'an County, Fujian Province in January,1910. He graduated in physics from Yenching University, Peiping in 1931. and, having passed the Sino–British Boxer Indemnity examination, went to England in 1934 for advanced studies. He received his Ph.D. at Cambridge University, England in 1938, and went to the United States in 1943 to work at Princeton University and Purdue University. He came back to China in 1956.

Professor Zhang Wen–Yu started his reseach work on nuclear physics as a graduate student. From the 1930's to the 1940's, he worked in the fields of the nuclear decay and the nuclear reaction in England and the United States, engaged in particular in measuring the α – energy spectrum of the natrual radioisotope. In the late 1940's, by studying the cosmic rays with the aid of a cloud chamber in the United States, he confirmed that there is no strong interaction between the muon and the nucleus, verified the existence of the muonic atom in his investigation of the muon absorption, thus initiating a new research topic about the muonic atom.

After coming back from abroad in 1956, he helped advance the extension project of the Luoxueshan Cosmic Rays Laboratory, Yunnan, China. In conjunction with Professor Xiao Jian, he conducted the construction of the biggest cloud chamber of the world at that time, a program whereby he also trained a number of cosmic rays researchers.

In the early 1960's, heading a group of Chinese physicists Professor Zhang Wen–Yu conducted experiments on high energy physics by using the accelerator in Dubna Joint Institute for Nuclear Research, U.S.S.R.. He classified well–known baryon resonances into nuclear and hypernuclear excitations and proposed a chart of baryon energy levels and transitions. According to this idea, he further studied $\Lambda^{\circ} + N$ scattering phenomena.

Together with his colleagues Professor Zhang made a proposal for developing our own high energy physics research, which met with approval by the State Council in 1973. As a result, the Institute of High Energy Physics, Academia Sinica was founded. Since then, researches on the high energy accelerator and the high energy physics have been pushed forward vigorously.

Professor Zhang Wen–Yu pays unremitting attention to the combination of theory with scientific experiment, laying emphasis on the development of the experimental science in the conviction that experiment is the basis of science. In the past few decades, he has been striving for establishing our own experimental bases and training our own high energy physicists. He spares no pains to achieve this aim.

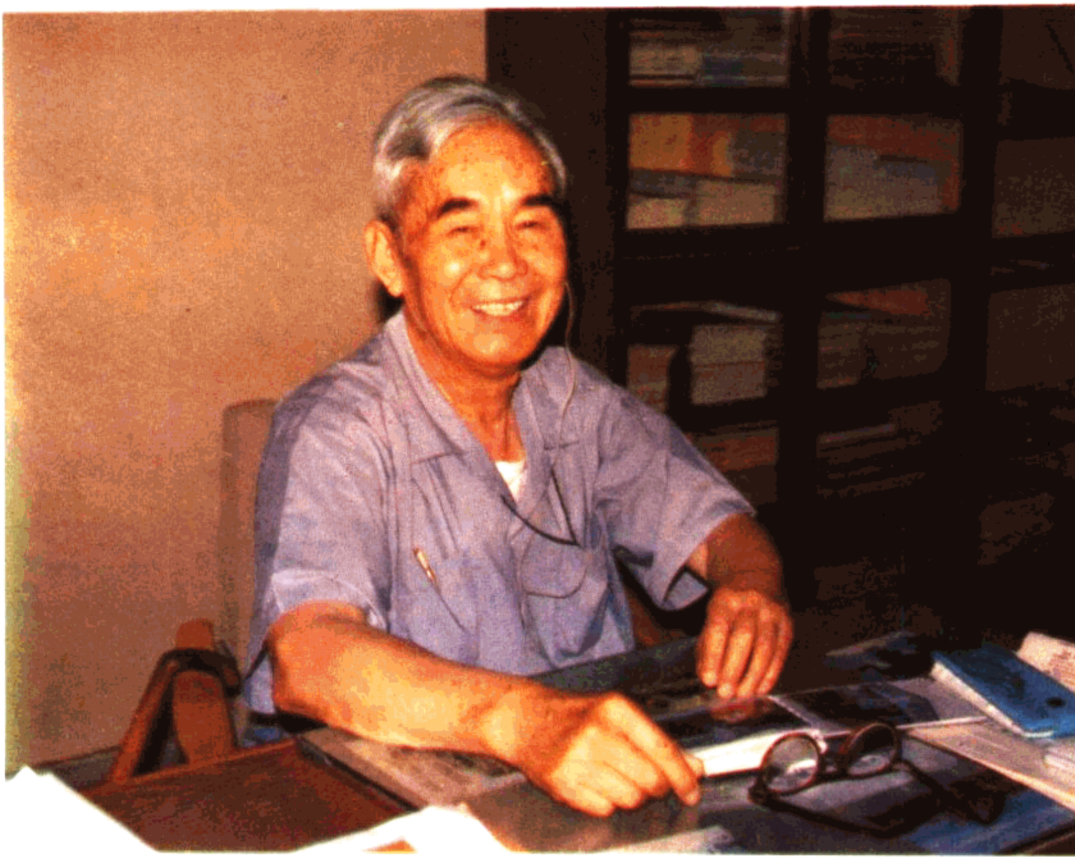
Professor Zhang Wen–Yu always pays great attention to the combination of research with education. He has taught in Sichuan University, China; Southwest Associated University, China; Princeton University, U.S.A.; Purdue University, U.S.A.; and Chinese University of Science and Technology. He made important contributions to the growth of the Department of Modern Physics in Chinese University of Science and Technology, and has trained lots of students, among them quite a few already distinguished.

In this book, we have collected part of his research papers written at various stages and expositions about the importance of the experimental science.

We have been friends for about sixty years. I firmly believe that the publication of this book will greatly inspire the young generation. They will be enlightened by the path explored by the old scientist and benefit not only from his knowledge and contributions, but also from his study style, dedication, and sense of historical responsibility.

Z. Y. Zhao.

June, 1988.



一九八四年六月于中国科学院高能物理研究所

徐胜兰　摄

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Air–Earth Electrical Current Measurement of Atmospheric Conductivity in Yenching

A Thesis Submitted to the College of Natural Sciences in Candidacy for
the degree of Bachelor of Science by Chang Wen–Yu
Peiping, China. May 1, 1931

PREFACE

This research was undertaken in the Department of physics, Yenching University for the degree of Bachelor of Science. The first part of this paper gives a general theory of Atmospheric Electricity leading to the Measurement of airearth electrical current. As to the experimental side the work suggested a possible and simple method of measuring Atmospheric Conductivity rather than intended to give sufficient data for drawing rigorous conclusion, since it should require a long time to take a series of conclusive readings.

For the suggestion of the subject as well as for valuable advice concerning material and experiment, the writer tenders grateful acknowledgment to Mr. William Band. The writer also takes pleasure in expressing his indebtedness to Dr. Y. M. Hsieh, chairman of the Department Mr. D. K. Yang and Mr. C. Y. Meng for their much advice and help in carrying out the experiment.

Yenching University,
April 19, 1931.

Chang Wen–yu

Some Thermo–Magnetic Electrical and Thermo–Mechanical Electrical Properties of Iron

A Dissertation Submitted to the Faculty of the Graduate Division in Candidacy for the Degree of Master of Science
Department of Physics
by Chang Wen Yu , Yenching University, November, 1932

ABSTRACT

Several hysteresis curves of the 'thermo–magnetic' E.M.F. as a function of longitudinal magnetising field are determined at various temperature differences. In any one curve there is a 'zero' displacement (apparent retentivity) making the cycle of the curve closed at a distance above the origin. When the hot end temperature of the test wire is 710℃ (cold end temperature is 18.5℃), the E.M.F. still increases its 'zero' displacement in the second half cycle, and the cycle is not closed. The E.M.F. is directed from the hot end to the cold end independent of the direction of the field. The upward 'zero' displacement of the hysteresis curves is found largely due to the effect in the transverse leads. Experiment seems to show that if this effect is subtracted from the results measured, the hysteresis curves can be reduced to that similar to Kurt Schneiderhan's resistance hysteresis curves①and Heinz Broili's E.M.F. hysteresis curves for nickel②.

In the absence of the magnetising field (sample demagnetised) a new E.M.F. is observed in the direction of the temperature differences, when a longitudinal mechanical tension is applied to the wire. This new E.M.F. has also its positive sign at the hot end of the wire and has the hysteresis effect with tension. At a temperature 720℃ of the hot end (cold end temperature 19.5℃) three successive cycles are continuously repeated. The first cycle is of negative E.M.F.; the second cycle has a part of negative and a larger part of positive E.M.F.; the third is entirely of positive E.M.F.. It increases with the tension in the experimental range of the weights so far added.

Two ordinary magnetic hysteresis curves one at 22.9 ℃ and the other at 275 ℃ are determined for the same sample, and the composition of which is chemically analysed.

Attempts are made to explain these results, showing that the E.M.F. is not proportional to $(J_0^2 - J_t^2)$, $(J_0 - J_t)^2$ or to $(|J_0| - |J_t|)^2$ where J_0 and J_t are the respective magnetisations at cold end and hot end. There is qualitative agreement with Gerlach's ideas concerning spontaneous magnetisation, but no quantitative comparison has been made.

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① Ann. der phys., 5 folge, 1931, B. 11, H. 4.

②Ann. der phys., 5 folge, 1932, B. 14, H.3.

THERMOMAGNETIC HYSTERESIS IN STEEL

By W.Y.CHANG, M.S.(Yenching), and WILLIAM BAND, M.Sc.,

Professor of Physics, Yenching University, Peiping, China
Received January 3, 1933. Read in title May 20, 1933

ABSTRACT

The temperature variation of a new hysteresis of the thermomagnetic electromotive force in a steel wire is described. The hysteresis is of a negative or abnormal form, with a maximum amplitude of about 2 μV. between up and down branches. The accuracy of the apparatus and method is critically examined, and an error of more than 0.5μV. in any reading is considered to be unlikely.

A qualitative explanation of the phenomenon is given in terms of Gerlach's① theory of spontaneous magnetization, and Broili's② results for nickel are discussed from the point of view of that theory.

1. INTRODUCTION

Several papers have recently been published describing the thermomagnetic e.m.f. in nickel and iron wires, and a hysteresis of the effect had been discovered for both metals. Band and T'ao announced③ a hysteresis of the e.m.f. in iron,but described no detailed properties of the phenomenon. After the present work has been commenced, Heinz Broili④ described the temperature variation of the hysteresis of a similar e.m.f. in pure nickel wires. The nickel hysteresis was a normal type with small retentivity and coercive field, but the iron curve was peculiar in that a permanent remanent e.m.f., which never disappeared during several cycles, seemed to have been produced by the field.

Unfortunately the curve published by Band and T'ao showed signs of a vagrant shift of zero e.m.f. during the cycle, and there was not much detailed investigation into this source of error. The results given in the present paper were obtained with apparatus similar to that used previously in these laboratories, and appear to have established the hysteresis on a more secure basis. The results are numerous and the various sources of error have been traced out carefully until a satisfactory selfconsistency has been attained.

The experimental arrangement in the present works is similar in principle with that used by Sir William Thomson⑤ when the longitudinal thermomagnetic e.m.f.was first discovered. That

① Becker, *Z.f. Phys.* 62,253;63,660(1930);Gerlach,*Ann.d.Phys.*8,649(1931).

② Heinz Broili,*Ann.d.Phys.*14,3(1932).

③ *Proc.Phys.Soc.* 44,166(March,1932).

④ Heinz Broili,*Ann.d.Phys.*14,3(1932).

⑤ *Math.and Phys.Papers*,2,267–307.

used by Broili was different in that a uniform temperature is maintained throughout each part of the specimen wire over which a non-uniform magnetic field exists. Broili's apparatus gave the pure longitudinal effect, and we should expect the present results to be somewhat more complex though not beyond analysis. In the present work the potential leads (of the same material as the sample) were taken transversely to the field through small holes in the solenoid and were thus non-uniformly magnetized by the field even though they were not uniform in temperature.

2 ACCURACY OF THE APPARATUS

A water-cooled solenoid of the Moullevigen[1] form gave fields up to 380 G. uniform to 0.1 per cent over a length of 40 cm. A heating coil of nichrome wire wound non-inductively gave temperatures up to 900℃ .uniform over 20 cm. and controllable to within 0.4℃ . A water-cooling jacket, also in the axis of the solenoid, gave uniform cool temperatures over 20 cm. which were found to remain constant within 0.1℃ .for periods of one hour.[2] Transverse leads of the same material as the longitudinal wire were taken out from the centres of these two uniform-temperature stretches and led through the solenoid into two Dewar flasks containing melting ice,where junction with the copper leads was effected. A Leeds Northrupp K-type potentiometer measured the e.m.f. between these two leads to within 0.5μV., against a standard cell placed in a thermostat maintaining a constant temperature to within 0.01℃ .The last change in temperature would involve a change in the standard voltage of 0.406μV. The temperature of the hot part was measured by means of an iron-platinum couple, of which the iron element was the part of the sample projecting from the hot oven through the end of the solenoid, figure 1. In every case the wire was kept under constant tension by the application of a weight of 2 kg.

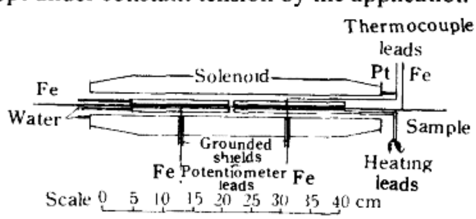

Figure 1 Section through the water-cooled solenoid, heating-coil and water-jacket. The Dewar flasks, potentiometer, galvanometer, ect., are omitted

After the work had been completed we realized that errors might have been introduced into the temperature-measurements by the magnetization of one of the thermo-elements. In our case iron—the specimen itself—was used against platinum.If the temperature of the iron element varied appreciably in a strong field the thermo-magnetic e.m.f. would be produced in the thermocouple, and only 0.2μV. would in our case be required to produce an error of 1℃ .

A very searching test was therefore carried out to check this error. The iron wire was stretched as before down the axis of the solenoid and a piece of platinum wire soldered on at the centre of the heating coil. Another platinum wire and a copper wire were also attached at the

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1 *F.d.Phys.*7,466(1898).

2 The water is obtained directly from an artesian well of considerable depth on the university campus, and its temperature is therefore almost independent of daily variations in surface temperatures.

same point to form an independent non–magnetic thermocouple to test for variations of temperature. Tests were then made over a complete cycle of the soleniod field at three different temperatures near 160°, 500° and 900℃. respectively. The reading of the platinum–iron junction was kept constant by adjustment of the heating current, and any variations in the other couple were noted. Variations of temperature of 1℃. could easily have been detected in the galvanometer reading, but no trace was found in fact at any of the temperatures. Even sudden changes in the field produced no detectable changes as between the readings of the two thermocouples, which were connected to two independent galvanometers of similar sensitivity.

We can explain this null result rather easily in our case. The iron element was kept at a uniform temperature throughout the strong part of the field, and not until the field is smaller does the temperature begin to vary; the e.m.f. produced must therefore have been less than that necessary to cause an error of 1℃. in the temperature reading. This error was found by test to correspond to less than $0.5\mu V$. in the thermomagnetic e.m.f. measured in the potentiometer.

Had there been an error in the measured temperatures of about 5℃. due to the magnetic field, a spurious hysteresis phenomenon would have occurred; in maintaining the thermocouple reading constant the temperature would have been taken through a cycle during the field cycle, and the thermomagnetic e.m.f. values obtained would not have been those corresponding to some one temperature–difference between hot and cold ends; there would have been variable errors amounting to the order of several microvolts. It thus seems that accuracy to less than 1℃. is desirable for the temperatures at both ends of the specimen, and that this accuracy is actually attained in the present work.

3. RESULTS

Analysis of iron sample. The wire investigated in these experiments was thermoelement metal manufactured by the Kahlbaum Company. The diameter was uniformly 0.57 mm. Two independent chemical analyses showed that the metal contained only 98.97 per cent of iron, the remaining 1.03 per cent being chiefly composed of carbon, manganese and sulphur, with traces of silicon and phosphorus; the latter were not exactly determined.

The ordinary hysteresis properties of the wire were determined by standard methods. It showed magnetic saturation under fields of 75 G. at 23℃.; the intensity of magnetization being 1110 c.g.s. units. There was retentivity of about 77 per cent. At 275℃. saturation was reached in fields of 30 G.,the intensity of magnetization being 740 c.g.s. units; and there was retentivity of 44 per cent. The coercive field necessary to reduce magnetization to zero after saturation was 15 G. at 23℃.and about 4 G.at 275℃.

At a later stage we hope to investigate the various related properties of the same specimen; magnetic resistance–change, specific–heat changes with magnetization, etc.

Hysteresis of the e.m.f. Figure 2 shows the hysteresis curves obtained when the hot end of the wire was at the temperatures respectively of 190°, 360° and 710℃.; in each case the cold end was between 19° and 20℃. The e.m.f. has been recorded as positive when it is directed from the hot end to the cold end of the specimen.

The initial e.m.f. in zero field was found in general to be about the same for any given temperatures after separate demangnetization processes. But sometimes it would differ by considerable amounts, even changing sign. Normally the initial e.m.f. would be positive from hot to cold end, but sometimes it would be in the opposite sense. This was probably due to incomplete demagnetization, as will be pointed out later in the discussion of the results. But the general form of the hysteresis was found to be independent of this initial discrepancy. A sample curve obtained when the initial e.m.f. was negative is shown in figure 4. After the first quarter–cycle