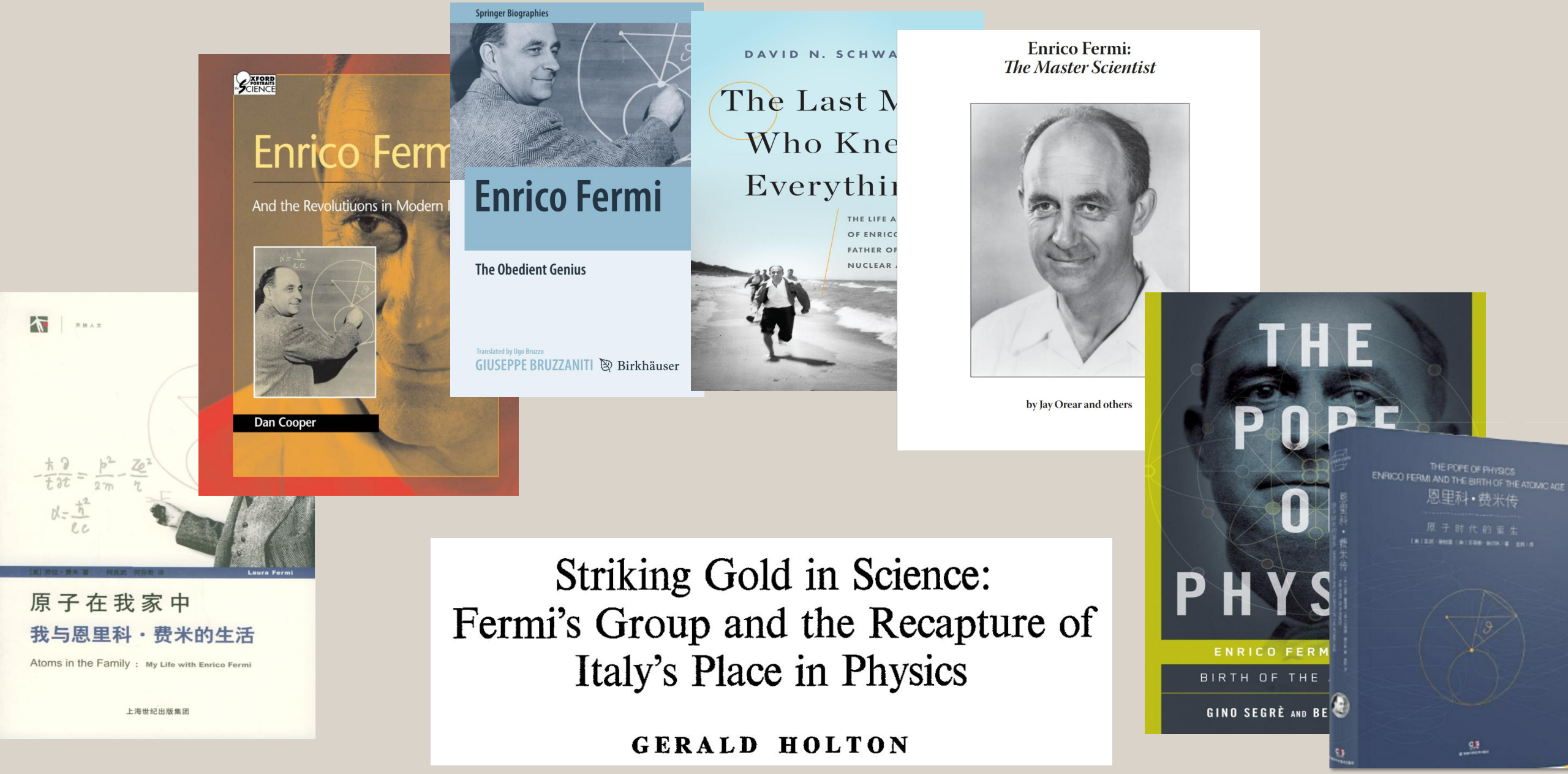
费米和费米学派

赵玉民

上海交通大学

“物理学家与物理学史”春季研讨会：学派与传承

CCAST，2024.5.20-2024.5.21



Striking Gold in Science: Fermi's Group and the Recapture of Italy's Place in Physics

GERALD HOLTON

费米和费米学派>>>

- **恩里科-费米**的成长、成就、生活和评价
- 费米指导的**研究生和年青同事**们
- 费米**在意大利研究组**的成长、辉煌和终结的探讨
- 费米学派的**总结**

• 什么是费米学派？见仁见智

说明:

因为时间关系，费米在美国期间指导学生的材料不少、但是比较零散，全面系统的总结没有见到。

我在私下与几位年长的老师讨论，但不够系统、也没有查证，因此这里不敢草率行事。费米**在美国期间客观环境变化很大，而他指导学生成就更大，**这部分应该以后花力气去分析挖掘。

费米的画像>>>

- 自学成才的历程
- 主要成就 (科学与教育)
- 日常生活
- 后世评价和启发

费米的画像>>>　　成长历程

- 他父亲阿尔贝托-费米的同事 **阿米代伊 (Adolfo Amidei，**工程师) 在1914年意外发现费米天分很高，先做几何方面，后来其他数理方面，在多方面帮助费米直到高中毕业报考大学**（Page 11-13)**。
- 1915年结识**恩里科-佩尔西科 (Enrico Persico)**: 并开始一起在**罗马广场上淘书 (Page 12);** 找到一本真正物理课本和二卷的拉丁文数学物理基础 (19世纪三十年代的神父Andrea Caraffa) 。后来又找到一本五千页百科全书式的法文物理学专著 (俄国物理学家Orest Kvholson) ; **这为费米打下了很好的数学和物理基础**。[**费米的笔记从此开始**，那些笔记陪伴他一辈子]。
- 罗马大学教授**皮塔雷利（Giulio Pittarelli）**在入学考试结束后(1918年) 确认费米确实懂得他考试中写下的东西，告诉他从来没有一个学生这么优秀。这对于费米自信心是极大的鼓励 **(Page 16)**

16岁时的恩里科·费米

费米的画像>>>　　成长历程

- 费米的博士指导教师**路易吉-普钱蒂** (Luigi Puccianti，1875.06.11 – 1952.06.09, 比萨高等师范学校, Scuola Normale Superiore of Pisa): 没有能力教费米新知识，但是从来没有嫉妒费米，他感激费米选择物理、而不是数学作为职业道路。 **（Page 17)**

  费米的课本: 庞加莱《混沌理论》、索末菲《原子结构和光谱线》、卢瑟福《放射性物质及其辐射》，文献如德文的《物理学杂志》（可能是那时比萨唯一读这本杂志的人)。**(Page 18)**

- 物理学家、政治家**奥尔索-马里奥-科尔比诺** (Orso Mario Corbino, 1876.04.30-1937.01.23) 1922年认识费米，是费米1922年取得博士学位后到1936年科尔比诺去世前、在意大利最重要的“保护伞”。 **（Page 22)**

费米的画像>>>　　成长历程

四位近乎同龄人(海森堡、泡利、狄拉克、费米) 同时代重量级学者**只有费米是自学成才的，而且身兼理论和实验；其他几位是做纯粹理论的，几乎不懂实验。**

为什么一流物理学家中只有费米身兼理论和实验?

可能的原因（年轻时通过自学打下的一流基础）：

(1) 在意大利物理被看作纯粹是一门实验课（**Page 17**)。大三的时候拿到了实验室的钥匙，允许自由使用仪器，与好友一起做各自的实验，热爱实验，甚至自力更生做设备。尽管他从1919年就有原创性的理论论文，他的博士学位论文也是实验方面(X-射线，原文1990年才找到, **Page 20**)。在佛罗伦萨大学时与拉塞蒂用很有限的设备和预算开展实验研究光谱学。在费米看来，物理学家做实验是很自然的。

(2) 费米学习相关课本、查阅近期的学术期刊，一旦掌握了相关内容就把他认为最本质的部分工工整整抄录的小本子上；包括加注的方程式（**这些是从十来岁就开始做的，后来一直用**)，并且特别喜欢计算或估算。在格丁根和莱顿的访问受到一定的理论熏陶。

这些一流基础使得他得以在理论与实验之间能快速切换 (有资助就做实验、没有条件就做理论)。

费米的画像>>>　　成长历程

恩里科-佩尔西科 (Enrico Persico):
费米哥哥朱利奥的同学，费米的终身好友，他们也是意大利前二位理论物理学教授。1915年结识、后来与费米合作研究，他和费米是意大利头两位理论理论教授。 **(Page 12)**

佛朗哥-拉塞蒂 (Franco Rasetti，1901.08.10 -2001.12.05):
物理学家、古生物学家、植物学家,是著名通才. 从1919年起,是费米的同学和终生朋友。费米大学时经常去他家里蹭饭,一起爬山。 **(Page 18)**

1927年，**埃米利奥-塞格雷**(Emilio Gino Segrè, 1959年获诺贝尔物理奖)、**爱德华多-阿马尔迪**（Edoardo Amaldi，意大利核物理研究所的创始人之一）、 **埃托雷-马约拉纳**（Ettore Majorana，1906.08.05 -1938.03, 著名理论学家，“宗教裁判所大法官”）加入，组成著名的四人团。 **(Page 52-53)**

埃米利奥·塞格雷、恩里科·佩尔西科和恩里科·费米（1927 年）

他领导的小组在三十年代已经把罗马建成了世界级别的物理前沿研究中心之一。

（昨天曹则贤老师的报告）“闲说玻恩学派”好像有一张片子里出现了费米。

费米在哥廷根并不怎么开心，其实是比较郁闷的。这两天我看到杨先生有一个说法，就是当时海森堡那些人那时候不大看得起费米。从传记里，作者们可能是为尊者讳，一笔带过。文学里可以这样，做研究就应该真实。如果把那段历史完整展示或大体复原起来，其实对于启迪后人也是很重要的。

费米的画像>>>　　主要成就：科学方面

- **1925年，**提出电子气体也遵循泡利原理，是量子统计方面的关键性概念(如理解白矮星稳定性、绝缘体与导体)。论文先在意大利**1926年春天**发表、后在《物理学杂志》发表。这是费米第一篇具有重大突破意义的论文。 **(Page 37)**

费米-狄拉克统计

以费米命名的重要物理学名词：

费米子、费米气体、费米面、费米能量、费米黄金规则、托马斯-费米近似、……

费米(长度单位)、镄(第100号元素)

费米的画像>>>　　主要成就：科学方面

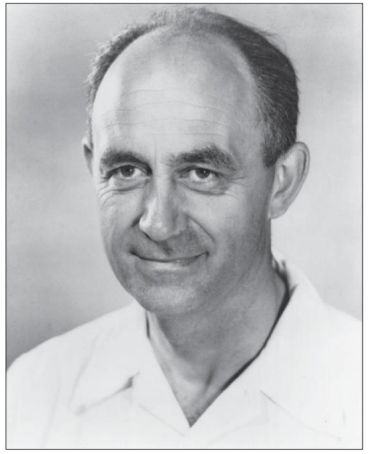
1934年费米发表贝塔衰变理论，这是**费米理论方面的代表作 (Page 71)。**

- “科学论文应该写成什么样子，这篇文章就是典范…… 没有花言巧语、没有矫揉造作，也没有承诺说这是长篇大论的第一步，只有事实。”，其中“没有花言巧语、没有矫揉造作”也是对费米本人的最好描述。费米在1933年圣诞节向阿马尔迪解释他的贝塔衰变理论，阿马尔迪觉得泡利的电中性粒子与查德威克的电中性粒子很容易混淆，建议在名称上明确区分，建议称为大中子、小中子，或中微子。小中子旨在意大利被沿用，中微子称为通用语言。 **（Page 72)**

- 这项成就后来被称为贝塔衰变中的“**费米跃迁**”（还有一种跃迁成为加莫夫-泰勒跃迁）

Enrico Fermi–The Master Scientist
by Jay Orear
Laboratory of Elementary Particle Physics
Cornell University

Enrico Fermi:
The Master Scientist



by Jay Orear and others

Chapter 31
Enrico Fermi

Chen Ning Yang
The Chinese University of Hong Kong
and
Tsinghua University, Beijing

I shall skip describing his beautiful contribution in 1930 to the theory of hyperfine structure, and come to the theory of beta-decay. According to Segré, Fermi had considered, throughout his life, that this theory was his most important contribution to theoretical physics. I had read Segré's remarks in this regard, but was puzzled. One day in the 1970s, I had the following conversation with Eugene Wigner in the cafeteria of Rockefeller University:

Yang: What do you think was Fermi's most important contribution to theoretical physics?

Wigner: beta-decay theory.

Yang: How could that be? It is being replaced by more fundamental ideas. Of course it was a very important contribution which had sustained the whole field for some 40 years: Fermi had characteristically swept what was unknowable at that time under the rug and focused on what can be calculated. It was beautiful and agreed with experiment. But it was not permanent. In contrast, the Fermi distribution is permanent.

Wigner: No, no, you do not understand the impact it produced at the time. Von Neumann and I had been thinking about beta-decay for a long time as did everybody else. We simply did not know how to create an electron in a nucleus.

Yang: Fermi knew how to do that by using a second quantized psi?

Wigner: Yes.

Yang: But it was you and Jordan who had first invented the second quantized psi.

Wigner: Yes, yes. But we never dreamed that it could be used in real physics.

费米的画像>>>　　主要成就：科学方面

1942年 12 月 2 日，科学家们第一次运转了他们的反应堆。他们是看到物质按照他们的意志而稳定地释放出它内部的能量来的第一批人。我的丈夫就是他们的领导人。

劳拉，《原子在我家中》

慢中子技术 （很重要）、第一座可控的原子核反应堆

- 费米从1938年底移居美国，1942年12月2日建立了世界上第一个原子核裂变反应堆（芝加哥一号）、可控的链式反应 **(Page 156-161).** “只要世界上还有故事在传送，第一个原子炉如何燃起的故事就会口耳相传，因为这肯定是人类在拓展认知过程中最具戏剧性的时刻之一 (美国哥伦比亚大学广播公司晚间新闻，在1954年费米去世时)”， **(Page 164).**

芝加哥一号团队部分人员合影

1943-1945年，参与核弹研制绝大多数关键环节 (page 164-199).

- 在曼哈顿计划中，奥本海默之于费米，就像中国在发展核弹过程中的钱三强之于邓稼先。奥本海默的贡献主要在于顶层的组织管理、知人善任，费米则作为其中最顶级、最权威的科学技术专家。

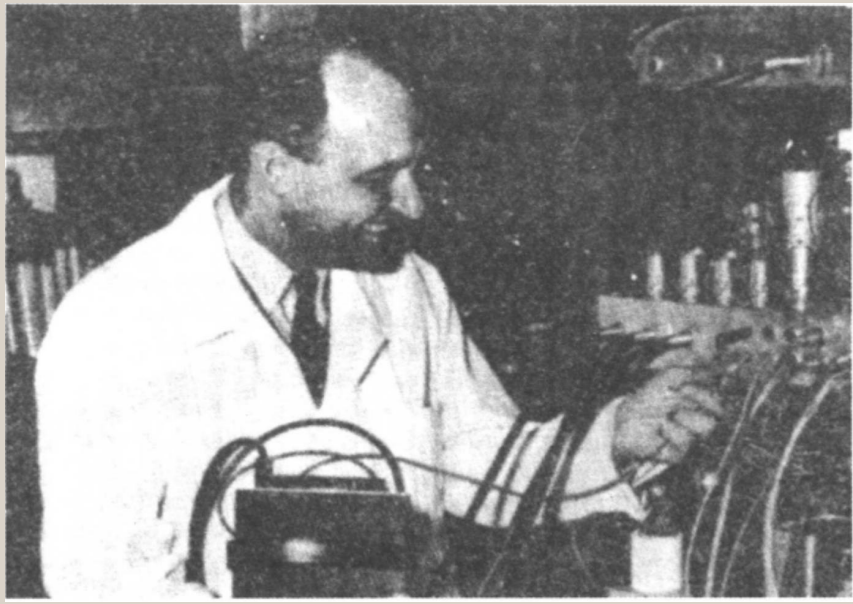
费米的画像>>>　　主要成就：科学方面

宇宙线的星际磁场加速机制 [PR75, 1169 (1949)]

费米-杨振宁 介子复合模型 [PR76, 1739 (1949)] (Page 218)

强子共振态等（52年6篇、53年4篇、54年2篇 Phys. Rev.， 共38篇）

Phys. Rev. 期刊上的第一作者论文共 24篇[slow neutron 只有8次citation]



PR 1,757 citations
On the Origin of the Cosmic Radiation
ENRICO Fermi
Phys. Rev. **75**, 1169 (1949) - Published 15 April 1949
Show Abstract

PR 926 citations
The Capture of Negative Mesotrons in Matter
E. Fermi and E. Teller
Phys. Rev. **72**, 399 (1947) - Published 1 September 1947
Show Abstract

PR 533 citations
The Ionization Loss of Energy in Gases and in Condensed Materials
Enrico Fermi
Phys. Rev. **57**, 485 (1940) - Published 15 March 1940
Show Abstract

PR 271 citations
Are Mesons Elementary Particles?
E. Fermi and C. N. Yang
Phys. Rev. **76**, 1739 (1949) - Published 15 December 1949
Show Abstract

PR 227 citations
Angular Distribution of the Pions Produced in High Energy Nuclear Collisions
Enrico Fermi
Phys. Rev. **81**, 683 (1951) - Published 1 March 1951
Show Abstract

PR 176 citations
On the Absorption and the Diffusion of Slow Neutrons
E. Amaldi and E. Fermi
Phys. Rev. **50**, 899 (1936) - Published 15 November 1936
Show Abstract

PR 165 citations
Interference Phenomena of Slow Neutrons
E. Fermi and L. Marshall
Phys. Rev. **71**, 666 (1947) - Published 15 May 1947
Show Abstract

PR 122 citations
Angular Distribution of Pions Scattered by Hydrogen
H. L. Anderson, E. Fermi, R. Martin, and D. E. Nagle
Phys. Rev. **91**, 155 (1953) - Published 1 July 1953
Show Abstract

PR 88 citations
Multiple Production of Pions in Nucleon-Nucleon Collisions at Cosmotron Energies
E. Fermi
Phys. Rev. **92**, 452 (1953) - Published 15 October 1953
Show Abstract

PR 84 citations
On the Interaction Between Neutrons and Electrons
E. Fermi and L. Marshall
Phys. Rev. **72**, 1139 (1947) - Published 15 December 1947
Show Abstract

PR 79 citations
Total Cross Sections of Positive Pions in Hydrogen
H. L. Anderson, E. Fermi, E. A. Long, and D. E. Nagle
Phys. Rev. **85**, 936 (1952) - Published 1 March 1952

PR 76 citations
The Transmission of Slow Neutrons through Microcrystalline Materials
E. Fermi, W. J. Sturm, and R. G. Sachs
Phys. Rev. **71**, 589 (1947) - Published 1 May 1947
Show Abstract

PR 69 citations
The Decay of Negative Mesotrons in Matter
E. Fermi, E. Teller, and V. Weisskopf
Phys. Rev. **71**, 314 (1947) - Published 1 March 1947

PR 68 citations
The Absorption of Mesotrons in Air and in Condensed Materials
Enrico Fermi
Phys. Rev. **56**, 1242 (1939) - Published 15 December 1939

PR 66 citations
A Thermal Neutron Velocity Selector and Its Application to the Measurement of the Cross Section of Boron
E. Fermi, J. Marshall, and L. Marshall
Phys. Rev. **72**, 193 (1947) - Published 1 August 1947
Show Abstract

PR 54 citations
Total Cross Section of Negative Pions in Hydrogen
H. L. Anderson, E. Fermi, E. A. Long, R. Martin, and D. E. Nagle
Phys. Rev. **85**, 934 (1952) - Published 1 March 1952

PR 49 citations
Multiple Production of Pions in Nucleon-Nucleon Collisions at Cosmotron Energies
E. Fermi
Phys. Rev. **93**, 1434 (1954) - Published 15 March 1954

PR 48 citations
Angular Distribution of Pions Scattered by Hydrogen
H. L. Anderson, E. Fermi, D. E. Nagle, and G. B. Yodh
Phys. Rev. **86**, 793 (1952) - Published 1 June 1952

PR 48 citations
On the Recombination of Electrons and Positrons
Enrico Fermi and George E. Uhlenbeck
Phys. Rev. **44**, 510 (1933) - Published 15 September 1933

PR 45 citations
Neutron Production and Absorption in Uranium
H. L. Anderson, E. Fermi, and Leo Szilard
Phys. Rev. **56**, 284 (1939) - Published 1 August 1939

PR 43 citations
Production of Neutrons in Uranium Bombarded by Neutrons
H. L. Anderson, E. Fermi, and H. B. Hanstein
Phys. Rev. **55**, 797 (1939) - Published 15 April 1939

费米的画像>>>　　主要成就：教书育人

费米直接指导研究生后来获得诺贝尔奖4人：

塞格雷 (Emilio Segrè)、张伯伦 (Owen Chamberlain)、李政道、

弗里德曼 (Jerome Friedman)

（下面会有费米研究生的详细列表）

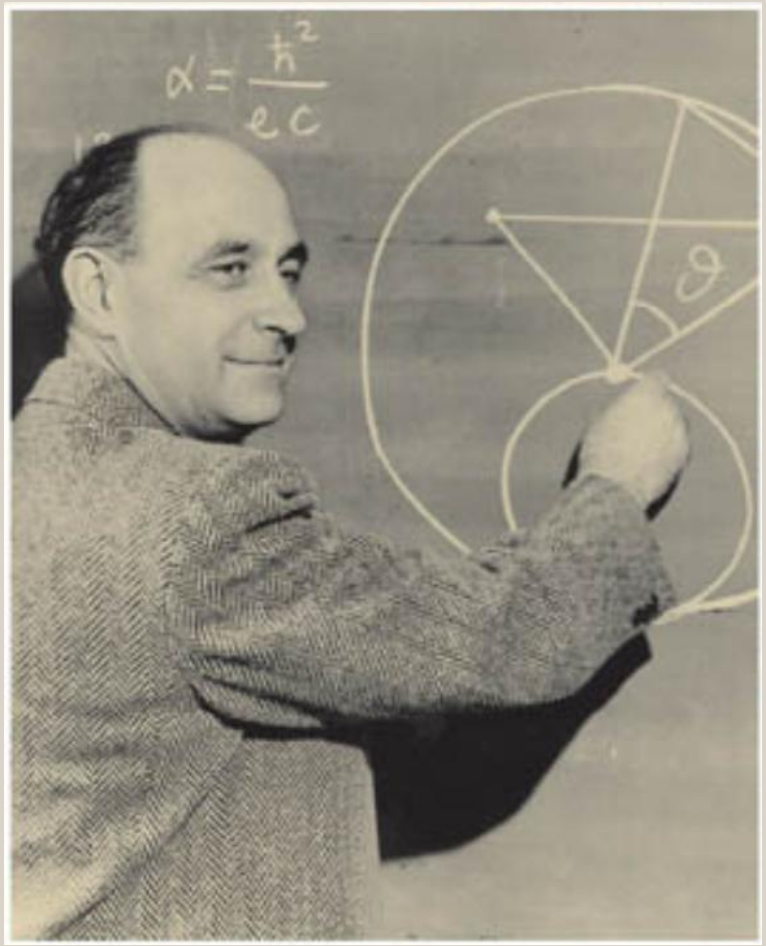
给与许多指导的学生：

斯坦伯格 (Jack Steinberger-是泰勒和费米共同学生)、

杨振宁（博士论文导师为泰勒、academic advisor 为费米)

受到直接影响和启发而获得诺贝尔奖的：

芝加哥大学的梅逸 (*Maria Goeppert Mayer*)



费米的画像>>>　　主要成就：教书育人

…… 仿佛一夜之间，物理学这门相对晦涩难懂、乏人问津的学科，变得对于本科生和研究生都极具吸引力，最好的学生纷至沓来…… 费米的核物理课程讲座笔记在学生中有认真而详尽的手写记录，深受学生喜爱…… 一传十、十传百，到了1949年芝加哥大学出版社影响了讲座笔记，编订为课本，到第六版发行时已经销售了2万册，而这些版本的形式都没有变过。费米关于量子力学和热力学的讲座笔记也得到了出版并广受赞誉，令那些无法聆听课堂的物理学爱好者能知其风范。

(Page 219-220)

费米的画像>>>　　主要成就：教书育人

定期邀请高年级学生到他的办公室小聚…… 办公室里没有舒适的沙发或成排的摆满书的书架，只有一张普通的金属桌子、几把椅子以及存放几堆笔记本的文件柜。这些笔记都有详细注解，是智慧的结晶、价值连城…… 话题范围很广，从抽象的黎曼几何到电路中电噪声的实际情况无所不包…… 费米似乎从来不会放过任何教学相长的机会，就连吃午饭的时候他也会和学生打成一片 …… 热烈的讨论肯定会有的，气氛是很随意的，跟教授先生们占尽风头的欧洲式正襟危坐比起来大异其趣……费米还将他跟学生的关系延伸到休闲娱乐的世界，展现初他相当可观的耐力和广为人知的好胜心…… （Page 220-221）

费米的画像>>>　　日常生活-名仕风度

芝加哥反应堆一号成功的时刻:

…… 大家也越来越感到胆战心惊，费米倒是一如既往，保持着静如止水的样子…… （Page 159)

"…… 就在大功告成的这一刻，他的脸上没有没有兴高采烈的表情。实验结果和预期一模一样，费米的头脑保持着冷静、镇定，没有停留在刚刚达到的重大成就上，而是在为工作的下一个紧要阶段运筹帷幄了"（康普顿的描述：Page 159).

费米身患绝症、不久离世前:

…… "告诉我钱德拉，等我死了我会变成一头大象再回来吗？"…. … 费米的玩笑 (Page 243)

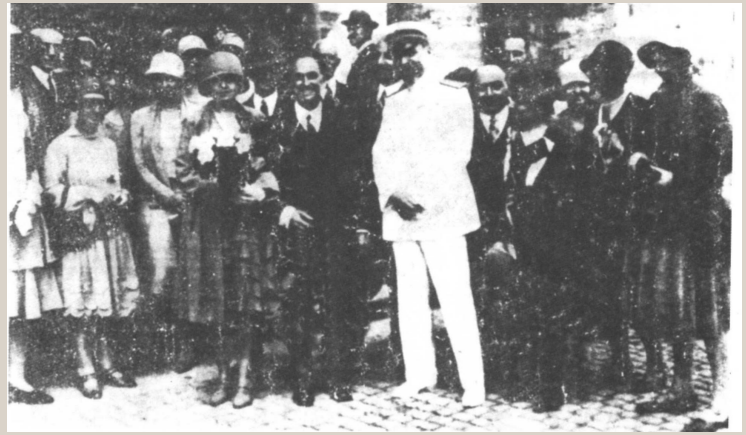
…… 乌拉姆对费米宽恕的能力、超人般的宁静和坦然感到惊讶…… （Page 245)

费米的画像>>>　　日常生活-家庭

- 他担任意大利百科全书的编辑顾问、（1930年）给《数学期刊》写稿、公共长篇文章等，为社会做贡献，同时也是为了挣钱。当时他(作为罗马大学物理系教授)的收入一个月90美元，不足以过上流社会的生活。而劳拉来自于上流社会，婚后生活期待也是如此。 **（Page 56)**
- 1928年出版的《原子物理学入门》没有挣到钱；但是高中教材就不一样了。现在他有劳拉帮助，给意大利高中写一本教材。他们二人每天6页，他们花了2年的假期时间写完（500多页）。这本书很多年了还在带来经济回报。 **（Page 57)**

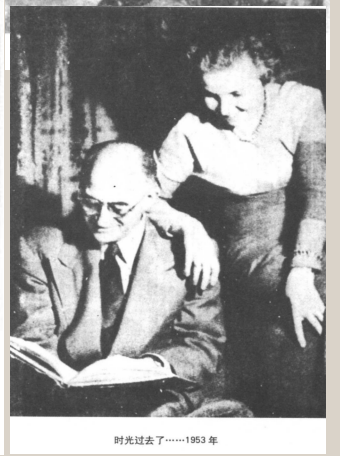
费米的画像>>>　　日常生活-家庭

- 夫人劳拉来自意大利犹太族，属于上流社会，父亲是海军上将。
- 女儿内拉学习艺术、在芝加哥大学教书30年。50岁时拿了教育心理学博士学位。费米很久以前对她说过：拿个博士学位，以防外一。(Page 247)。
- 儿子贾德青春期阶段，费米是缺席的，因此有一些抑郁和孤立的倾向。(Page 241) 贾德后来拿了分子生物学博士学位，换过职业，最后在英国定居。在剑桥大学医学研究委员会工作。(Page 247)



微型“标致”：需要把发火钥匙和手摇把合用才能发动

费米和“小动物”内拉

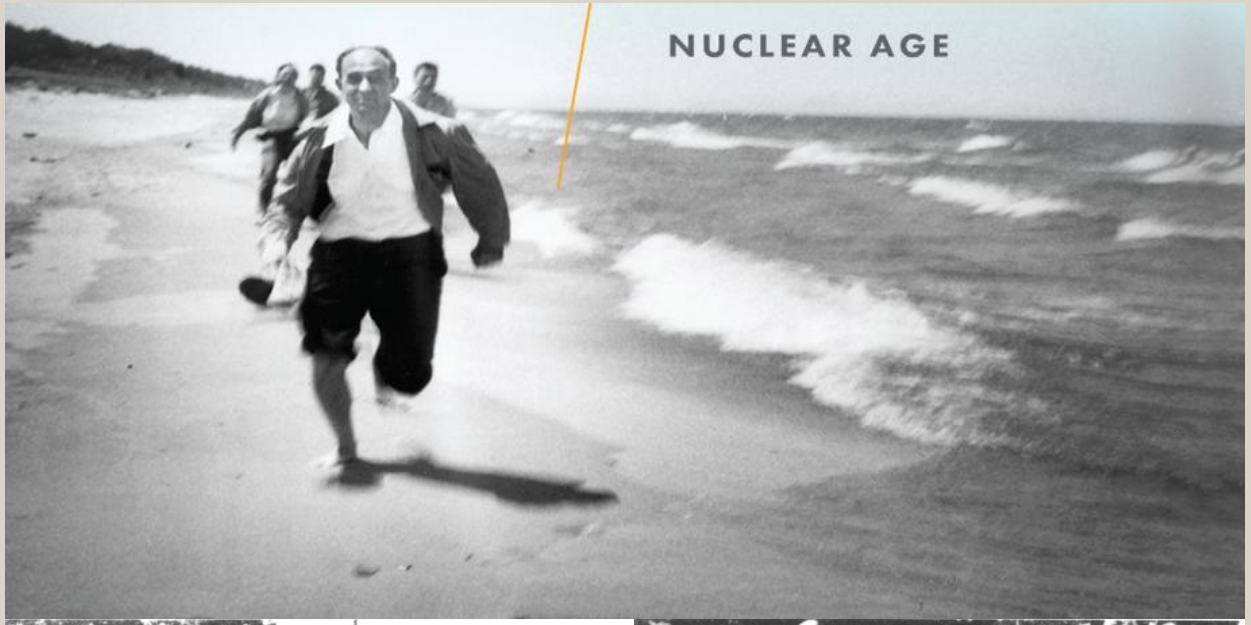


时光过去了……1953 年

费米的画像>>>　　日常生活-个人喜好

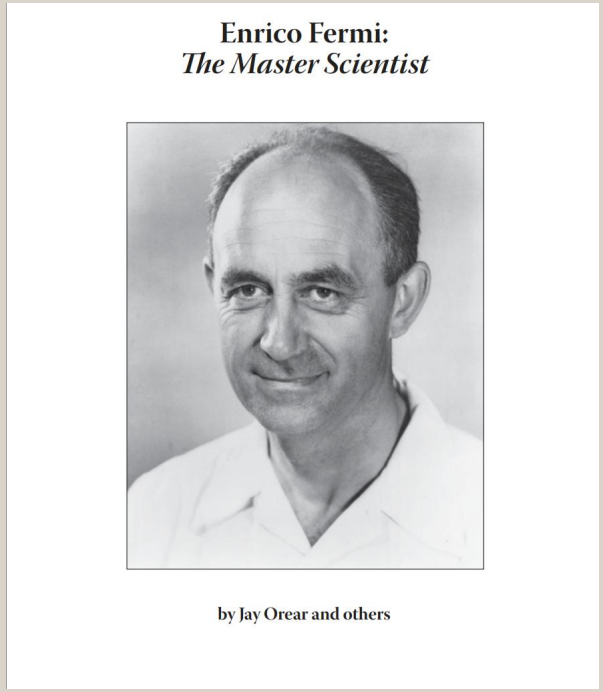
- 体育运动 — 网球、远足、游泳
  (体能好、顽强、好胜心),
  (p.46, p.147, p. 220, p.240)

- **“这位意大利人五短身材，姿态远远谈不上优雅，却被大家看作气势汹汹的网球运动员，会在正午大太阳地下奔跑击球，直到把每一位对手打趴下为止”** (Page 221).



费米使他自己和他的滑雪杖保持良好状态

在阿尔卑斯山滑雪：费米和佩尔西科准备出发



Enrico Fermi–The Master Scientist
by Jay Orear
Laboratory of Elementary Particle Physics
Cornell University

Chapter 24 | *Glimpses of Fermi in Chicago and Los Alamos by Dick Garwin*

People have said that Enrico was competitive, and he was. He would also like to bet. You could provoke him into a bet, which was somewhat unwise. *(laughter)* I had to make a vacuum chamber for my work, which was a piece of plastic pipe, and he bet me it would collapse when I evacuated it, but he had estimated and I had figured, and it didn't collapse.

费米的画像>>>　　日常生活-个人习惯：测量、计算、估计

- 马约拉纳的计算速度与费米难分轩轾 …… 在此之前他们都认为，没有人能跟费米相提并论 **(Page 55)**.
- 费米的大拇指通常就是他的现成量尺。把它放在挨近左眼处、闭上右眼，他就能够测出一道山脉的距离、一棵树的高度，以至于一只小鸟的飞行速度。(**Page 8, 劳拉-《原子在我家中》**）。
- “小玩意”在测试场所顺利引爆。费米平心静气计算爆炸能量的故事成了一段传奇 …… 在某种程度上他也就是把原子弹引爆当作又一次物理实验而已…… 费米后来告诉劳拉，在这次特别“实验”中他注意力过于集中，以至于到没有注意到爆炸的声响。 **(Page 198)**
- 费米问题：如芝加哥有多少钢琴调音师？有多少个加油站？[为了鼓励学生提高估算技能] ***(Page 222)***
- 费米方法：将复杂困难问题分解成小的、可以解决的部分,从而以最直接方法迅速解决问题。**(Page 221)**

费米的画像>>>

后世评价

Chapter 22 | *Working with Fermi by Robert Wilson*

Los Alamos.[7] At Harvard, Wilson published a seminal paper, "Radiological Use of Fast Protons", which founded the field of proton therapy.[17][18]

Robert Rathbun Wilson (March 4, 1914 – January 16, 2000) was an American physicist known for his work on the Manhattan Project during World War II, as a sculptor, and as an architect of the Fermi National Accelerator Laboratory (Fermilab), where he was the first director from 1967 to 1978.

…… 费米协助奥本海默说服鲍勃-威尔逊换岗 …… 费米同意每周五午饭后跟他碰面讨论物理学作为诱惑，这位不情不愿的科学家立马承认："这下子就是叫我出卖灵魂我也愿意啊！" **(Page 184)**

…… 物理学家费曼正在绞尽脑汁去想明白他得到的一些结果，费米刚好路过，停了下来。费曼描述接下来发生的事情："我跟费米说我正在想这个问题，然后我开始讲那些结果。他说：'等一下，在你告诉我结果之前，让我想想看。它的结果应该是如此如此（他是对的），而结果之所以如此是因为这般这般。对此有个极为明显的解释' – 他正在做的就是我本来擅长的事情，然而还要好上10倍。对我来说，这可真是领教了" **(Page 189)**

Enrico Fermi–The Master Scientist
by Jay Orear
Laboratory of Elementary Particle Physics
Cornell University

course, for Fermi, who was clearly the best). Fermi was a modest person and liked to be treated as one of the crowd. Just to give one example of his modesty, even though one of his many great achievements was the discovery of Fermi statistics, he *always* referred to it as "Pauli statistics."

Chapter 4 | *My First Meetings with Fermi*

Chapter 7 | *My Ph.D. Thesis*

One of the duties of a thesis adviser is to teach the student how to do good scientific writing. Fermi took this responsibility seriously. He made me go through four or five different drafts. He took special delight each time he found a spelling or grammar mistake. One thing he taught me was to be overly generous about giving references to other people in the same field. In an early draft I had intentionally left out reference to a worker in a nearby university. I knew that person's work well enough to judge that it was not worth reporting. Fermi taught me that what I had done was a no-no. But also Fermi had taught

Chapter 7 | *My Ph.D. Thesis*

Fermi took his rule seriously that one should not leave out any reference. I had showed him a case where a postdoc of Hans Bethe had published a solution for the low-energy phase shifts in pion-proton elastic scattering and ignored my more comprehensive solution that had been published earlier in an Italian journal. I rarely observed anger from Fermi, but this time he uttered something along the lines that the president of the American Physical Society (Bethe) should know better than this. I suggested that Bethe probably wasn't even aware of the obscure publication in question, but Fermi insisted he was going to complain to Bethe anyway. There may be no connection, but four years later I received an offer of associate professor with tenure from Bethe and Wilson at Cornell.

Chapter 8 | *Fermi Intuition*

after the Berkeley Bevatron had been running on both electronic and nuclear emulsion antiproton searches, not one antiproton had been seen. Also no antiprotons had been seen in cosmic rays. Murray Gell-Mann had just returned from Berkeley with these negative results, which he was relating to Fermi and me in the hall just outside our office doors. Murray said, "Now we know there is no antiproton." Then Fermi said in a very definitive and loud manner, "There *is* an antiproton." We grad students used to joke, "Fermi had an inside track to God." And sure enough, within a month of that definitive pronouncement, the first antiprotons were discovered at the Bevatron. The group leaders of the electronic experiment at Berkeley (Chamberlain and Segré) were former grad students of Fermi.

Chapter 9 | *Fermi Humor*

Parts of this one page are discussed below. We shall see that he does plan jokes days in advance, and from the second lecture where we can hear both Fermi laughter and audience laughter we note that he laughs heartily at his own jokes. As far as I can tell, the style of humor and delivery shown in these documents are just as I remember and to me they give some feeling of his humble, friendly, and cheerful personality. My comments are

Chapter 20 | *Fermi at Chicago by Valentine Telegdi*

an H? (2) One of the best pastimes in Los Alamos was fishing. Emilio Segré enjoyed it and tried to convince Fermi to come along with him. Fermi did not seem to show any interest in doing so. Segré then tried to convince him of the intellectual merits of fishing: "You see, Enrico, it's not so simple. The fish are not stupid, they know how to hide. One has to learn their tricks." Fermi replied, "I see, matching wits!"

Fermi displayed hardly any of the behavior patterns that one (rightly or wrongly) often attributes to Italians: loud speech; vivacious gestures; gregariousness; fondness for wine, food, and song; concern for well-tailored appearance; assertion of authority ("you don't know whom you are speaking to," etc.). He possessed, however, one Italian quality, one that many American intellectuals lack: a total absence of psychological complexes (prewar Italy was the country with the smallest number of psychoanalysts per capita).

Chapter 12 | *Fermi and Politics*

The Cobalt Bomb

My first political discussion with Fermi was in the form of a question asked by Art Rosenfeld and me. After the first H-bomb test the possibility of a cobalt bomb producing widespread radioactive contamination was rather obvious. We asked Fermi for his opinion on this and he spoke freely to us. He gave a response I did not expect. He said the military leaders would not rely on a weapon whose effects had never been tested and that the long-range air patterns are too unpredictable. Now that I am older and perhaps wiser, I agree with Fermi on this.

Chapter 18 | *Pilgrimages to Rome by Hans Bethe*

I don't know when he came to the office; it was too early in the morning for me to observe, *(laughter)* but I did observe that he always left the office precisely at noon, and he always returned from lunch precisely at 3:00. You could essentially set your watch by his movements. On the other hand, Placzak and I, of course, came to the office at very irregular hours; in my second year, I usually came about noon when Fermi was about to leave, and the very dignified custodian, so to speak, of the institute said, "Those Germans are really crazy people: when other people work, they sleep; when other people eat, they work; and so on." *(laughter)*

Chapter 18 | *Pilgrimages to Rome by Hans Bethe*

Carl Sagan: We seem to be a little ahead of schedule and Hans says he'd be happy to take some questions if there are any on history or physics.

(question from audience): "Did Fermi comment at all on the discussions between Niels Bohr and Albert Einstein on quantum mechanics?"

Bethe: Not to my knowledge. That was not the kind of thing he would get engaged in. *(laughter)*

费米的画像>>>　　后世评价

在美国他是最伟大的物理学家，有人称他为大写的物理学家。费米的影响不在于政治影响力 (奥本海默曾有政治影响力)；也不在于公众形象，爱因斯坦吸引更多目光。芝加哥人喜欢费米，声称费米是芝加哥的。（Page 214）

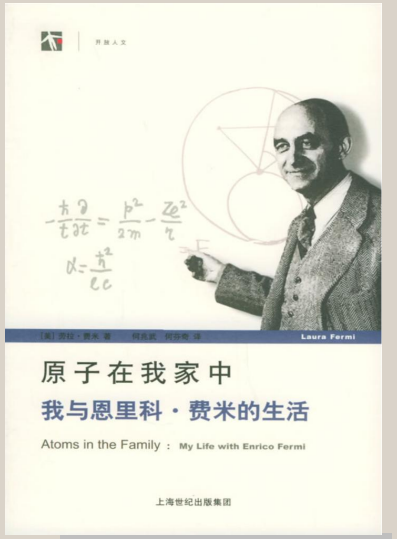
…… “盖尔曼和我被他纯粹的决心和他对物理学的挚爱彻底征服了。有那么些时候，我们甚至不敢看他的脸” （杨振宁，Page 243-244).

[象任何英雄和伟人一样]，恩里科-费米既是他所处时代的创造者，也是时代的产物。“一位造时势的英雄人物，同时时势也早就了这位英雄”。（Page 249）

《中国科学报》
(2012-01-18
B4 人物)

李政道

讲到费米，他是特殊的，他具有极强的将抽象的事情具体化的理论分析能力，而且他又能设计和执行极有效的实验证明。可以简而言之地说，他拥有极不平凡的天才，能将不同的、极难了解的自然现象都演变成清晰化、明朗化的能力。费米是一位极伟大的理论和实验物理巨人，他也是一位很善教导很能引人深入的超级老师。



杨振宁

恩里克·费米是20世纪所有伟大的物理学家中最受尊敬和崇拜者之一。他之所以受尊敬和崇拜，是因为他在理论物理和实验物理两方面的贡献，是因为在他领导下的工作为人类发现了强大的新能源，而更重要的是因为他的个性：他永远可靠和可信任；他永远脚踏实地。他的能力极强，却不滥用影响，也不哗众取宠，或巧语贬人。我一直认为他是一个标准的儒家君子。

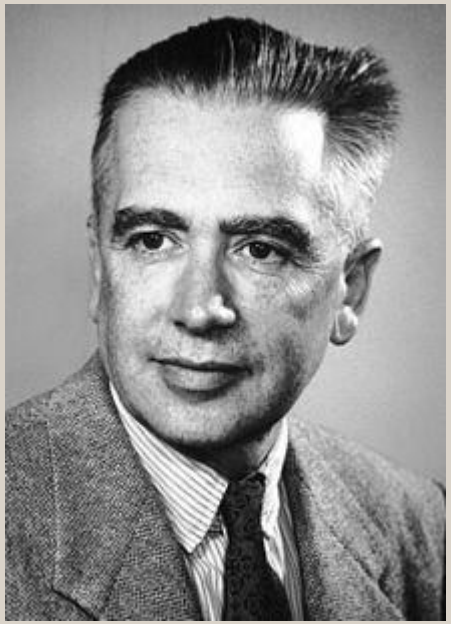
在朗道心目中，费米属于1.5级别的物理学家（昨天廖玮老师的报告）；如果加上教育方面的伟大成就，费米应该属于20世纪第一等的物理学家。

另外，那些大人物臧否其他学者的那些说法，也不一定太当真。有些可能也是一时兴起，有些带有个人和时代的偏见。

费米的弟子们>>>

指导的研究生+青年同事

费米指导的研究生-1： *Emilio Segrè*



(1905.02.01-1989.04.22)

1959年 诺贝尔物理奖

[似乎只有这一个奖… …]

1928年7月 Laurea degree （等同博士学位，80年代之前惯例）

1939 移居美国 （犹太身份）

曾与吴健雄合作分离出 Xe-135 (反应堆停机因素);

与 Makenzie 合成鉴别 85号元素;

与Seaborg 等人产生 Pu-239

与 Owen Chamberlain 发现反质子 [Clyde Wiegand and Thomas Ypsilantis 没有获奖]

1939年 Lawrence 给他很低的工资，后来还克扣一部分… …

喜欢摄影，记录大量事件和人物，去世后捐赠给美国物理研究所

费米指导的研究生-2： Edoardo Amaldi

(5 September 1908 – 5 December 1989)

中微子neutrino 的命名者

慢中子技术的发明人之一

反质子（几乎同时）发现者

许多院士头衔… …

大学教授的儿子

在费米1938年全家转借领诺贝尔奖机会去美国之前

一直在费米指导下工作和合作, 是意大利核物理研究所

和欧洲空间研究组织的创立者之一、

CERN 最早期的秘书长(general secretary)、

引力波研究在欧洲的先驱

原子物理、原子核物理、引力波、粒子物理

200 多篇论文 … …

中学教材、大学教材、科学史 (如马约拉纳传)

费米指导的研究生-3: *Ettore Majorana*

1906.08.05-1938.03.25(失踪) –一说 很可能死于 1959年前后

2006年 设立 Majorana 奖章

1929年 Laurea 学位(相当于博士学位)

共9篇文章(几乎)全部用意大利文发表，因此成果几十年被外界忽略。

Exchange force; Relativistic wave functions;

Majorana fermion, Majorana equation,

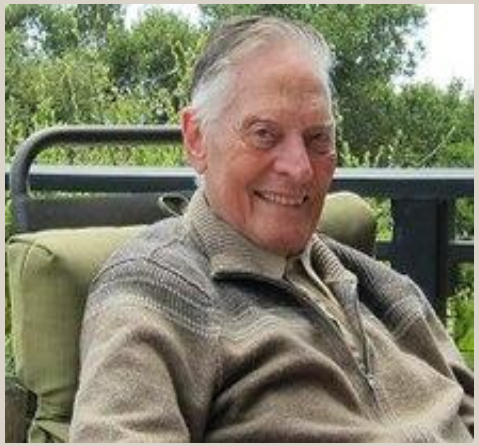
Majorana representation.

其中，中子的解释(约里奥-居里实验）没有发表

In 1938, Enrico Fermi was quoted as saying about Majorana:

"There are several categories of scientists in the world; those of second or third rank do their best but never get very far. Then there is the first rank, those who make important discoveries, fundamental to scientific progress. But then there are the geniuses, like Galileo and Newton. Majorana was one of these."

费米指导的研究生-4: Geoffrey Foucar Chew



(June 5, 1924 – April 12, 2019)

1962 美国物理学会 Hughes 奖

1969 劳伦兹 奖

2008 马约拉纳奖

美国科学院、科学与艺术学院的院士

1944-1946 芝加哥大学 博士学位

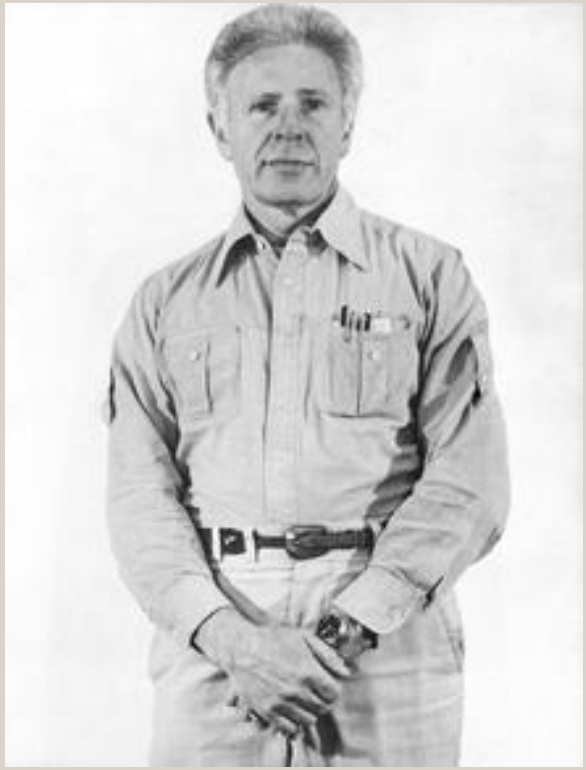
1957-1991 UC Berkeley

六十年代十分流行的关于强相互作用的S 矩阵理论

学生 David Gross （诺贝尔物理奖）

学生 John H. Schwarz (弦论提出者之一)

费米指导的研究生-5: **Marvin Leonard Goldberger**



(October 22, 1922 – November 26, 2014)

曾任加州理工学院的校长

1943-1945 曼哈顿计划中在费米指导下工作

1948年 芝加哥大学 博士学位

(*Interaction of High-Energy Neutrons with Heavy Nuclei*)

1957-1977 Professor at Princeton University

1978-1987 President of the California Institute of Technology

科学成就:

Crossing symmetry (with Murray Gell-Mann)

Goldberger-Treiman relation (with Sam Bard Treiman)

费米指导的研究生-6： Harold Melvin Agnew

(March 28, 1921 – September 29, 2013)

In a 2005 BBC interview, Agnew stated, "About three-quarters of the U.S. nuclear arsenal was designed under my tutelage at Los Alamos. That is my legacy.“

美国科学院和工程院的院士；得过费米奖等

1941年底、高中毕业、体育很好；珍珠港事件后本想和女朋友一起参军打仗，Joyce C. Stearns 劝说他参加芝加哥1号工作。

1943年去Los Alamos 参加核弹研究

1945年作为轰炸机上的现场学者参加轰炸广岛拍摄影带

战后在费米指导下获得博士学位(和夫人一起借住在费米家)

1948年硕士学位、1949年博士学位

[与李先生、杨先生、张伯伦、斯坦伯格先后的同学]

1950年 热核计划、新墨西哥州参议员(1955-1961)

北约总部的科学顾问（1961-1964）

1964年 美国核武器工程部主任

… …

1970-1979 洛斯阿拉莫斯国家实验室的主任

1982-1989 白宫科学顾问

费米指导的研究生-7： Owen Chamberlain

(July 10, 1920 – February 28, 2006)

诺贝尔物理奖获得者-1959

1942 参加曼哈顿计划（跟随塞格雷，伯克利、洛斯阿拉莫斯）

1946 芝加哥大学 导师费米

费米鼓励他放弃理论物理、做实验物理

1949 博士学位

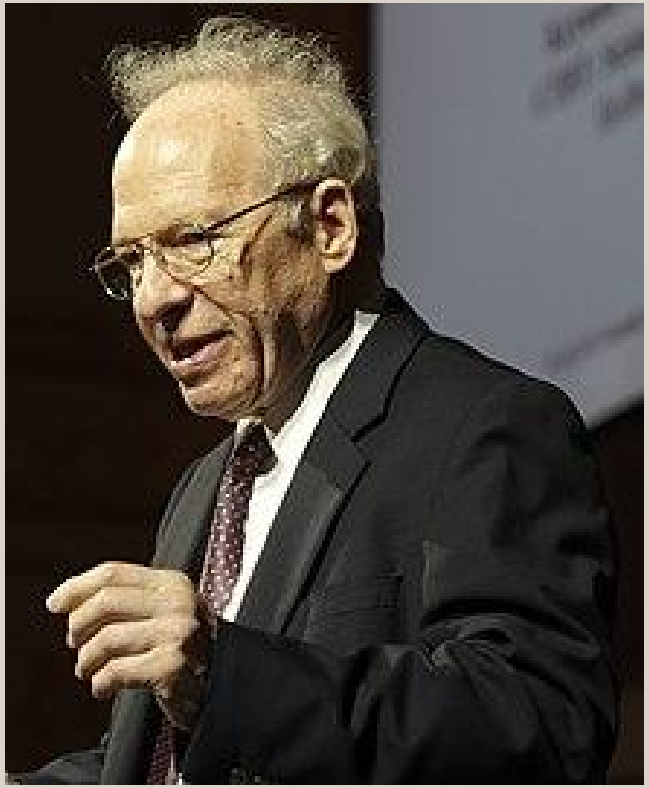
1955 质子散射实验 发现反质子

发明时间投影室

反战人士(反对越战)、反核运动

1989 退休(因帕金森综合症)

费米指导的研究生-8: Richard Lawrence Garwin



(born April 19, 1928)

One of Fermi's students, Marvin L. Goldberger, claims that Fermi said that "Garwin was the only true genius he had ever met".

1947-1949年 (21岁) 芝加哥大学 博士学位

1952年 第一枚氢弹的实际设计者

第一个间谍卫星设计者之一

核磁共振成像技术的发明者之一

引力波、激光打印机、触屏技术

[费米临终前曾去探望费米]

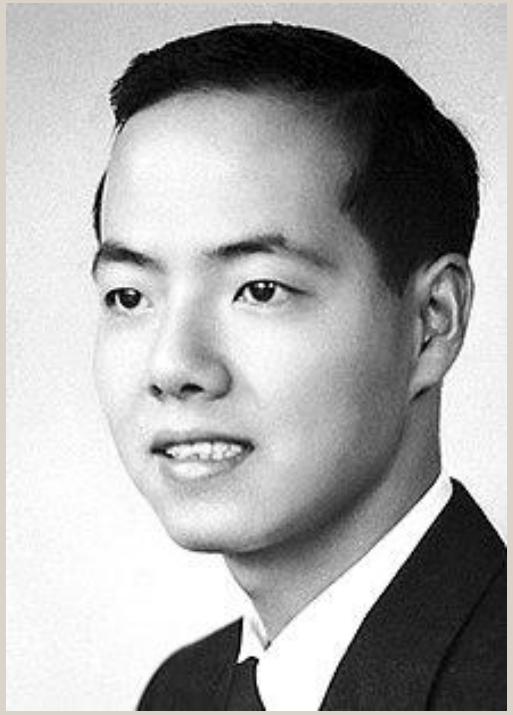
三任总统科技顾问… …

美国军控和核不扩散咨询委员会主席… …

对美国弹道导弹威胁评估委员会主席、

国际安全与军控国家研究委员会成员

费米指导的研究生-9：李政道（1926.11.24- 至今）



1957年 诺贝尔物理奖、爱因斯坦科学奖
……
1995年 中国政府友谊奖
2007年 日本旭日奖章
2009年 改革开放三十年中国最有影响的海外专家

1946-1950年 芝加哥大学博士学位

Hydrogen content of white dwarf stars

1953- 哥伦比亚大学

[其中1960-1963年 Princeton 高等研究院]

1964-1984年 哥伦比亚大学费米讲座教授

1984年至今 校级教授

1986年 CCAST 中心主任

……

2018年 李政道研究所名誉所长

费米指导的研究生-10： Sam Bard Treiman (没有照片)

(1925.05.27-1999.11.30)： Oersted Medal (1985):supervising two dozen+ graduate students; active in CUSPEA

在纪念费米的书中没有见到他的名字…… 奇怪…… 【他的导师：费米、John Alexander Simpson】

1949（Bat）1950 (Mast) 1952 Ph D. with Fermi; working at **Princeton University**, professor (1958-63); Eugene Higgins Professor of Physics (1963-77); Dept Chair (1981-87); Chair of University research board (1988-95); **supervisor of Steven Weinberg**.

•1957 (with J. David Jackson and Henry Wyld) - definitive theory of allowed beta decays, taking into account time and parity violations

•1958 (with Marvin Goldberger) dispersion relations analysis of pion and nucleon beta decay, culminating in the *Goldberger-Treiman* relationship *for the charged pion decay amplitude. This work eventually led to the hypothesis of the partially conserved axial vector current, known as PCAC and to a deeper understanding of spontaneously broken chiral symmetry of the strong interaction.*

•1962 (with C.N. Yang) Treiman-Yang angle test for single pion exchange dominance

•1966 (with Curtis Callan) derivation of the *Callan–Treiman relations* for K meson decay.

•1971 (with David Gross) scaling in vector gluon exchange theories, coining the term *twist* for the difference between the dimension and spin of an operator.

•1972 (with Abraham Pais) deriving the implications of weak neutral currents for inclusive neutrino reactions.

费米指导的研究生-11： Arthur Hinton Rosenfeld

(1926.06.22-2017.01.27)
“Godfather of energy efficiency”

2005 年 Enrico Fermi Award
2011 年 Global Energy Prize
2011 年 National Medal of Technology
2016 年 Tang Prize

1947(?)-1954 年 芝加哥大学博士学位

In 1954, after earning his Doctor of Philosophy in physics, and with a recommendation from Fermi, Rosenfeld accepted a position as a teaching physicist at the University of California, Berkeley.

In 1957, he became professor of physics, later professor emeritus, and was one of the founding members of the international Particle Data Group. He developed the **reputation of being a workaholic**, arriving to work very early, taking a dinner break with his family, and continuing to work until 2 a.m.

费米指导的研究生-12: Jerome Isaac Friedman

(born March 28, 1930)

俄罗斯移民后裔，犹太族、少年时显示很高艺术天分

爱因斯坦的相对论书吸引转向物理

1956年 芝加哥大学 博士学位 (导师 费米)

1968-1969　电子-核子散射实验[核子有结构]

无神论者、参与和平运动

1990 诺贝尔物理奖(电子-核子散射实验)

费米指导的研究生-13： **Mildred Dresselhaus (女)**

(November 11, 1930 – February 20, 2017)

the "Queen of Carbon Science“

在 MIT 做教授 57年！ 奖励包括 National Medal of science, Enrico Fermi Award 等。

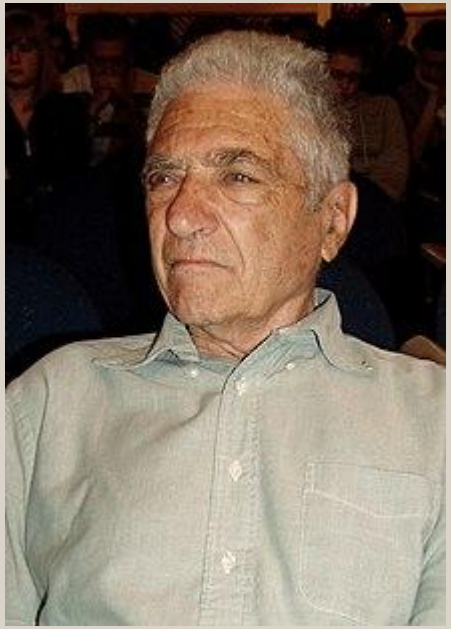
1958年 芝加哥大学 博士学位 （但是费米1954年11月去世）

她在芝加哥大学攻读博士学位，在恩里科·费米（Enrico Fermi）的指导下研究磁场如何影响超导体。德雷塞尔豪斯认为费米训练了她“像物理学家一样思考”。在芝加哥期间，她会和他一起走进实验室，畅所欲言地谈论研究方向和新机会。费米的妻子劳拉（Laura）每个月都会为他的研究小组做一次意大利菜，德雷塞尔豪斯说，“正是那个家庭的氛围和友好让我们真正喜欢物理学”。虽然她只认识费米一年，但他的教学、学生监督和公共服务方法给德雷塞尔豪斯“留下了持久的印象”。

Mildred Dresselhaus、 Jerome Isaac Friedman 分别是在费米去世3年以上、1年以上的时间之后完成博士论文的。为此我们请教了** 专家(比较复杂、不愿具名、不是靠谱)，据说：Edward Teller 在这方面代替费米做了不少工作，但是没有见到相关文件。

[本来希望请教李先生。李先生现在身体尚好、而记忆力则已大不如前。]

其他“准”学生： Jack Steinberger， Chen Ning Yang

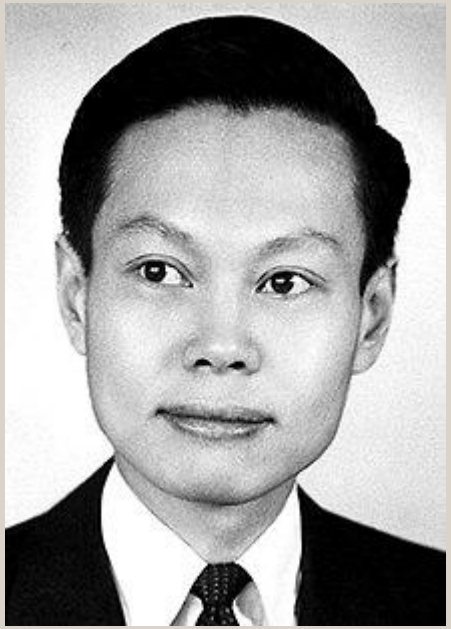


(1921.05.25-2020.12.12)

1988 Nobel Prize of Physics

Academic advisors:

Edward Teller and Enrico Fermi



(1922.10.01-)

1957 Nobel Prize of Physics

Doctoral advisor: Edward Teller

Academic advisor: Enrico Fermi

其他“准”学生： John Hinton (寒春)

Joan Hinton with her brother Bill at her farm in Beijing

Joan Hinton's great-grandfather was the mathematician George Boole, and her grandfather was the mathematician Charles Howard Hinton.

Joan Hinton was shocked when the US government, three weeks later, dropped nuclear bombs on Hiroshima and Nagasaki.

She left the Manhattan Project and lobbied the government in Washington to internationalize nuclear power.

She studied physics at Bennington College and graduated in 1942 with a bachelor's degree in natural science. In 1944, Hinton earned a doctorate in physics from University of Wisconsin.

Hinton was in Los Alamos for the Manhattan Project.

Under the supervision of Enrico Fermi, she calibrated neutron detectors to be used in the Alamogordo test.

1966年，为了表彰寒春对中国畜牧业的贡献，中国相关部门给予她副部级待遇

The Four Fermi Student Reunions: October 13, 1991; December 3, 1992; September 29, 2001; December 1, 2001.

Photo taken by Roger Hildebrand at the end of the second Fermi reunion. (left to right): Back row: A. Wattenberg, M. Glicksman, G. Farwell, R. Schluter, V. Telegdi, J. Friedman, O. Chamberlain. Front row: A. Rosenfeld, U. Haberscheim, J. Hinton, G. Yodh, J. Orear.

寒春（Joan Hinton，1921年10月20日—2010年6月8日，最早获得在华居住权的外国友人）

The Four Fermi Student Reunions

I. October 13, 1991

Cornell hosted a dinner for all of Fermi's former students who were attending the symposium (of which there were at least a dozen) and their spouses. This first reunion was held in the boardroom of the Statler Inn on October 13, 1991, the night before the Fermi Symposium. We shared the experiences we had with Fermi as well as the excellent food and service of the Cornell Hotel School.

II. December 3, 1992

Art Rosenfeld suggested that we have another student reunion a year later where we could relate what each of us had done since leaving the University of Chicago. A very convenient date that would fit into most of the Fermi students' schedules was the fiftieth anniversary of the first nuclear chain reaction that was celebrated at the University of Chicago on December 2, 1992. Since I had the names and mailing lists, I suggested to Roger Hildebrand that a Fermi student reunion be held the morning after the December 2 symposium. Roger made arrangements at his end that included meeting in a spacious Physics Department lounge. We decided to invite Chicago physics faculty and grad students to sit in. The meeting ended with a group photo and a free lunch. Dick Garwin and Jack Steinberger had to leave early so they missed out on the photo and lunch. The remaining Fermi students and associates are shown in Figure 4.

III. September 29, 2001

The 2001 Chicago reunion was an open meeting organized by Jim Cronin that was scheduled on the exact day of Fermi's one-hundredth birthday. Unfortunately I could not be in two places at the same time and I had accepted a prior invitation. I gave two talks at the Rome Fermi Congress during the four days that straddled Fermi's birthday. The Fermi associates who were able to attend the third reunion were George Farwell, Jerry Friedman, Dick Garwin, Murray Gell-Mann, Maurice Glicksman, Murph Goldberger, Roger Hildebrand, Joan Hinton, Darragh Nagle, Bob Schluter, Jack Steinberger, Al Wattenberg, Lincoln Wolfenstein, Courtenay Wright, and Gaurang Yodh. Jim Cronin is compiling these talks into a book titled *Fermi Remembered*

IV. December 1, 2001

The fourth reunion took place as part of a West Coast two-day Fermi Symposium held at UCLA on November 30–December 1, 2001, also during the year of Fermi's hundredth birthday. It was titled "The Life and Times of Enrico Fermi" and included a Fermi's student roundtable consisting of Harold Agnew, Richard Garwin, Marvin Goldberger, Nina Byers, Steven Moszkowski, Arthur Rosenfeld, William Slater, Gaurang Yodh, and me.

梅逸 (Maria Goeppert Mayer)

非费米学生

受费米影响很大

1949年壳模型理论

1963年诺贝尔物理奖

正是从这个阶段开始，她的主要工作转到原子核壳层结构理论方面。这时的实验数据已经越来越多地表明原子核有壳层结构，然而在理论上还不能充分理解其机制。突破性进展是在1949年初，在这里她得到了费米很大帮助。这方面有一段有趣轶事的场景回忆：费米和迈耶在她的办公室里讨论的时候，费米被叫出去接一个长途电话；在出门之前转身问了一个与轨道-自旋耦合的问题。十分钟之后费米回来后，迈耶立即非常激动地开始解释她的想法；而迈耶有一个习惯，就是一旦激动起来就慷慨陈词、滔滔不绝(不容插嘴而且语速很快)，而费米则习惯于一个比较慢而详细的解释；因此费米就只能笑着离开了，说：等你明天不那么激动的时候，你再给我解释解释吧... ...[In an account relayed by Joe Mayer, Maria Goppert Mayer attained a critical insight while speaking with Enrico Fermi.**]**

Taken from 赵玉民的博客文章：核科学群英谱(7)：核结构标准模型建立者 迈耶和延森
https://blog.sciencenet.cn/blog-3404169-1344559.html

Twelve "trainees" of Fermi who received (or should have received) the Nobel Prize in physics:

1. T. D. Lee
2. Frank Yang
3. Owen Chamberlain
4. Emilio Segré
5. Jack Steinberger
6. Jerry Friedman
7. Dick Garwin
8. Jim Cronin
9. Maria Mayer
10. Hans Bethe
11. Murray Gell-Mann
12. S. Chandrasekhar

Taken from

Book **Enrico Fermi:** ***The Master Scientist***

Chapter 18 | *Pilgrimages to Rome by Hans Bethe*

earned his Ph.D.) (7) **Dick Garwin** was also a student of Fermi and if the Nobel Prize had been awarded for the experimental discovery of parity violation in pion-muon and muon-electron decay (as it should have been), it would have been shared by him. (8) **Jim Cronin** was formally a grad student of Sam Allison (who was very busy as director of the institute). However, his office was next door to Fermi's office, and Jim frequently visited with his close neighbors and also attended Fermi's courses and Fermi student group meetings. It was agreed that Fermi would help out with Allison's students. Cronin received the Nobel Prize for the discovery of CP violation. (9) **Maria Mayer** was not a

product of the two of them. One of Fermi's "trainees" from the Italian days was (10) **Hans Bethe** as a postdoc. Hans made many discoveries including the thermonuclear energy source of stars. This is a total of 10 followers of Fermi receiving Nobel Prizes in a short period of time. I don't know of any other physicist who has left such a strong mark on his followers. A possible eleventh is **Murray Gell-Mann,** who joined Fermi on the Chicago faculty as a young instructor. Millie Dresselhaus has told me that while at a party in his house, Fermi had patted Murray on the back and predicted that he would become a Nobel Prize winner. A more recent Nobel Prize winner who also had spent a year or two working with Fermi is (12) **S. Chandrasekhar**. Depending on how we count, Fermi training led to 10, 11, or 12 Nobel Prizes. I estimate the probability that an existing Nobel Prize winner in physics "give birth" to another winner is less than 1/10. So if this is purely random, the probability of one winner giving birth to 10 other winners would be one-tenth to the 10th power or one in 10 billion, which is essentially impossible. The explanation is that Fermi was very creative and the world's best trainer or teacher of physics. Also, his known talent and pleasant personality attracted the best students. According to the talk

费米学派>>>

- 什么是费米学派？见仁见智

在英文维基百科上，有关于哥本哈根学派的解释

The **Copenhagen School** is a term given to "schools" of theory originating in Copenhagen, Denmark. In at least four different scientific disciplines a theoretical approach originating in Copenhagen has been so influential that they have been dubbed "the Copenhagen School"

•Copenhagen School (quantum physics) — centered on the theories developed by Niels Bohr

•Copenhagen School (theology) — centered on a theoretical framework developed by Thomas L. Thompson, Niels Peter Lemche and others. Also called the School of Minimalist Theology.

•Copenhagen School (international relations), security studies — centered on ideas by Barry Buzan, Ole Wæver and Jaap de Wilde.

•Copenhagen School (linguistics) — centered on the linguistic theories developed by Louis Hjelmslev, and later formed into the "Copenhagen school of functional linguistics".

•Copenhagen School (painting)

费米学派>>>

- 什么是费米学派？见仁见智

在英文维基百科和中文百度百科上，有关于格丁根学派的特指 (The **Göttingen school** of history)

The University of Göttingen was the original centre of history as an academic discipline, and became a major centre for globally-orientated anthropology. The school itself was one of the newest universities in Europe, having been founded in 1734 by Gerlach Adolph von Münchhausen, and the first to include the obligation to conduct and publish research alongside lecturing. The historians of this school sought to write a universal history by combining the critical methods of Jean Mabillon with that of the philosophical historians such as Voltaire and Edward Gibbon.

中文搜索：格丁根学派也指：哥丁根数学学派(高斯、黎曼、希尔伯特、外尔、诺特、冯-诺伊曼、柯朗等)。

在《基础教育百科全书·数学卷》（设计书）中，提到的数学学派有：伊奥尼亚学派、毕达哥拉斯学派、诡辩学派、智人学派、埃利亚学派、原子论学派、雅典学派、柏拉图学派、亚里士多德学派、亚历山大里亚学派、格丁根学派、柏林学派、彼得堡学派、意大利代数几何学派、法国函数论学派、直觉主义学派、逻辑主义学派、形式主义学派、普林斯顿学派、莫斯科学派、函数论学派、拓扑学派、剑桥分析学派、波兰学派、华沙学派、利沃夫学派、布尔巴基学派等。

哥廷根物理学派，是建立量子力学的物理学派。是高斯奠定的哥廷根数学学派学术传统适逢物理学具有特殊发展需求阶段的必然产物。 玻恩与弗兰克是这个学派的核心人物。

费米学派>>>

- 什么是费米学派？见仁见智

中文百度搜索：费米学派

非凡的物理直觉："教父"费米与他的费米学派

中国科学院高能物理研究所 2024-03-09 19:52 北京

以下文章来源于赛先生， 作者邢志忠

费米学派和意大利物理学的崛起--费米学派成功经验分析与借鉴

恩里科·费米是20世纪杰出的理论物理和实验物理学家,诺贝尔奖获得者,"最后一位19世纪传统意义上的物理学全才".他在1927年领导一个学派所进行的一系列重要工作轰...

刘月蕾 - 《大自然探索》

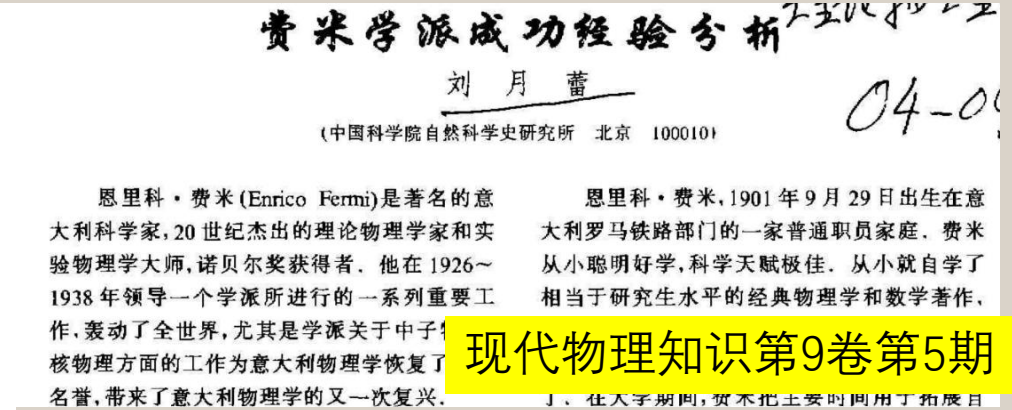
被引量: 0 发表: 1997年

两度辉煌:费米学派

本书从意大利物理学家费米的生平说起,阐述他因为标志着人类进入核时代的关键性实验,使"罗马的费米学派"成为科学领域瞩目心,以及移民美国的费米因为实现人类原子能...

莫少群 - 两度辉煌:费米学派

被引量: 7 发表: 2002年



费米学派成功经验分析

刘 月 蕾

(中国科学院自然科学史研究所 北京 100010)

04-0

恩里科·费米(Enrico Fermi)是著名的意大利科学家,20世纪杰出的理论物理学家和实验物理学大师,诺贝尔奖获得者. 他在1926~1938年领导一个学派所进行的一系列重要工作,轰动了全世界,尤其是学派关于中子[illegible]核物理方面的工作为意大利物理学恢复了名誉,带来了意大利物理学的又一次复兴.

恩里科·费米,1901年9月29日出生在意大利罗马铁路部门的一家普通职员家庭. 费米从小聪明好学,科学天赋极佳. 从小就自学了相当于研究生水平的经典物理学和数学著作,

现代物理知识第9卷第5期

费米学派>>>

- 什么是费米学派？见仁见智

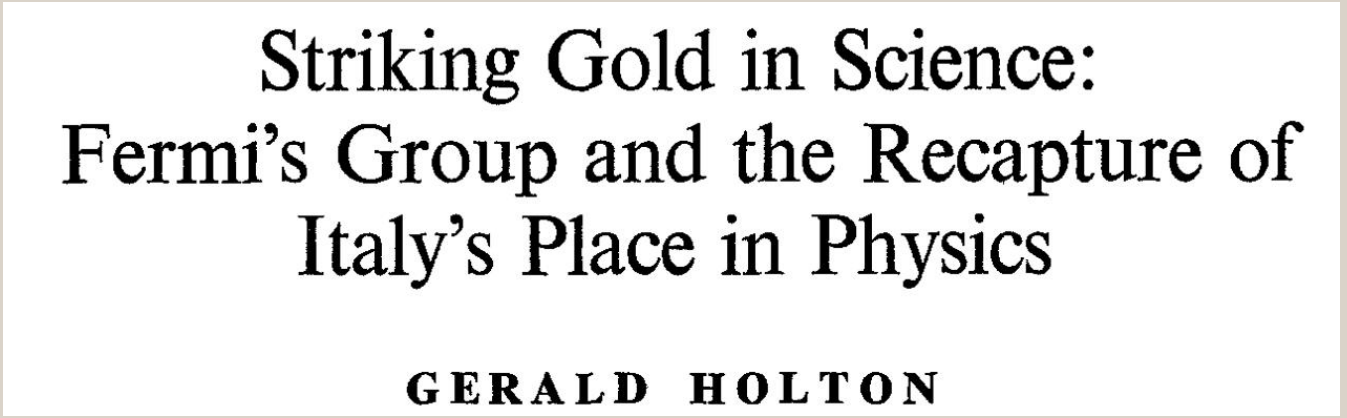
费米学生们都盛赞费米之伟大、费米之教导，说他待人包容宽厚、智慧而不失厚道，大家都感激和喜欢他。费米的学生散布在基础科学、高科技、政治和文化交流多个领域，**每个人非常成功。**

费米的学生没有一个人在费米后面做那些补遗的事情，都向前进！向前进也是费米最重要的科学特质。

费米英年早逝：假如再给他20年寿命，那么今天物理学也许有所不同！

费米学派>>>

- 什么是费米学派？见仁见智



费米学派研究对象：**罗马大学期间的科研小组、访问者**

\+ 芝加哥大学期间的教学、科研、讨论

费米学派>>> • 什么是费米学派？见仁见智

Striking Gold in Science:
Fermi's Group and the Recapture of
Italy's Place in Physics

GERALD HOLTON

这是Gerald Holton 一篇关于费米学派一篇40 页的长文。这里摘录其中个别分析和讨论。

费米属于**最低限度的教条主义者、最大程度理性主义者** (the least Dionysian, the most Appollonian)

因此导致**他发明慢中子技术的那次灵机一动，是他职业生涯中的唯一例外[但这是重要的大事]**。

effect of placing a piece of lead before the incident neutrons. And instead of my usual custom, I took great pains to have the piece of lead precisely machined. I was clearly dissatisfied with something: I tried every "excuse" to postpone putting the piece of lead in its place. When finally, with some reluctance, I was going to put it in its place, I said to myself: "No, I do not want this piece of lead here; what I want is a piece of paraffin." It was just like that: with no advanced warning, no conscious, prior, reasoning. I immediately took some odd piece of paraffin . . . and placed it where the piece of lead was to have been.[1] **(page 1)**

费米学派>>> • 什么是费米学派？见仁见智

THE turning points of modern history have sometimes the character of mythological events. Such an event took place in Rome one morning in October 1934, in an upstairs room at Via Panisperna 89A, an old physics laboratory of the University of Rome. There Enrico Fermi and his young collaborators, to their surprise, came upon a key observation from which one may well date the effective beginning of the nuclear age. It was the

现代历史转折点有时是很神秘的事件。

慢中子技术的发现可以作为核时代的肇始。

费米学派>>>

- 什么是费米学派？见仁见智

Fermi's Mastery as Physicist and Teacher

as working chiefly in experimental physics; in fact, until 1934 he seems to have thought of himself only occasionally as an experimentalist. He was indeed a master of theoretical physics, including its mathematical aspects.

A key to understanding Fermi's mastery, however, lies neither in his experimental skills, nor in his theoretical insight, nor in his encyclopaedic knowledge, nor in his striving for fundamental simplicity and parsimony, but rather in the subtle balance of all these. While it is commonly agreed that physicists more or less of the class of Bohr, Rutherford and Einstein in the early and mid-twentieth century may each have had an advantage with respect either to large new theoretical ideas or to purely experimental intuition, nobody combined these capabilities—which are often so separate—as effectively as Fermi did. The commonly accepted ideal for the style of doing physics is today much closer to Fermi's than was the case even in the 1930s. (page 4)

Very similar stories of the disdain of theorists for the work of experimentalists are also common. Nothing of this sort, however, could be charged against the Fermi group.

Another important aspect of Fermi's position was that by preference and necessity he was self-taught. His first contact with physics came when he bought a second-hand book on the elements of physics as a 14-year-old

Again, virtually all his colleagues and former students agree that Fermi was unmatched as a teacher, and that his teaching reflected the characteristics which have been discussed above. For example, his introductory course was enormously wide-ranging in the subject-matter covered.[13] More important, however, is the fact that much of his teaching was carried out by thinking aloud before the class—in a rational, organised way—about the subjects on which he was then engaged in first-hand study himself. The joy which teaching gave Fermi makes it likely that it was one of his most intense human relationships, as well as being yet another opportunity for self-education. This fact, together with the

费米学派>>>

- 什么是费米学派？见仁见智

费米具有教师和科学家的两种天分

首先是费米对于物理学家的洞察力。他实验技术没得说，一个特点是他一般避免用复杂的大设备。费米还是理论学家，在1934年之前主要还是理论方面，实验是副业。他的理论很好，包括他的数学方面也很好；他在21岁时已经发表的关于概率论、广义相对论方面的论文就已经为他赢得了很大关注。**他对于各种物理现象都有很深的思考，他的长处在于“一以贯之”的策略**，把那么多理论变成几条原理和实例。

费米的过人之处不在于实验技术水平，不在于理论的洞察力，不在于他广博的知识，也不在于他对于简约模式的追求，而**在于这些方面微妙的平衡**。在此之前的学者，要么这方面强、要么另一方面强，这些方面对于一般的学者通常是分离的，而费米则做到了统一。现在理想模式的物理学家更接近于费米这种模式。

费米学派>>>

- 什么是费米学派？见仁见智

费米作为教师和科学家的才气

Madame [Joliot-] Curie had little respect for theory. Once when one of her students suggested an experiment, adding that the theoretical physicists next door thought it hopeful, she replied, "Well, we might try it all the same". Their disregard of theory may have cost them the discovery of the neutron.[11]

约里奥-居里夫妇可能正是因为瞧不起理论而错失了发现中子的荣誉。许多地方也有类似的故事。在费米这里绝不会如此。费米是自学成才的，所以在教学上就很独特。他在讲课举例时往往具有很宽的题材，而且是在课前才独立想到的、天马行空式的、但是生动而组织很好的；这也是他与他人交往最多的场所。这也使得他十分轻松地建立一个以他为中心的、生动的小组。在意大利如此，在美国也是如此。

费米学派>>>

- 什么是费米学派？见仁见智

On Fermi's Scientific Style

Possibly even more important than the scientific excellence and pedagogic capabilities of the central figure in the Rome group was the particular methodology—conservative and pragmatic at the same time—for the choice of problems and the conduct of research. Here we encounter a distinctive style which was crucial to the success of the Italian group as a whole. In a sense, it represents a fusion of Fermi's personal characteristics and his scientific experience on the one hand, and the needs and opportunities for physics research on the other, within the setting given by existing scientific institutions and the state of science in the world at the time. (page 5)

费米学派>>>

- 什么是费米学派？见仁见智

A good deal of Fermi's enterprise—and that of his later colleague in Rome, Rasetti—is already visible here: his ability to organise, to distinguish between essentials and incidentals, to make very reasonable,[16] simple assumptions and short cuts contrary to current "rules", to make a commonsense, qualitative approximation before any detailed quantitative solution, to improvise—and to succeed. Neither aesthetic nor other philosophical or quasi-metaphysical principles—except that of simplicity—could preoccupy or delay Fermi.[17]

(page 6)

费米学派>>> • 什么是费米学派？见仁见智

Another style which Fermi's group eschewed was that associated with Niels Bohr, who in many ways was completely different from Fermi, and who in turn tended to regard Fermi's solution as too simple to be profoundly important. As one observer has said: "Bohr is such a bad authority on these [Fermi] papers because Bohr really had it in his mind that there was some profound problem with neutrinos and energy and so on, and didn't want to have it solved except in a mystical and deep way. It was solved by Fermi in 'too elementary' a way."[19] Bohr's favourite procedure was to drive contradictions patiently to their ultimate extreme, and to ponder the ensuing conceptual conflict as a necessary preparation for its ultimate resolution.[20] From the beginning, Fermi quite consciously and explicitly rejected as somewhat mystical and too philosophical the approach of Bohr, and indeed of others whose theoretical work dominated the scene. Fermi would say, though smiling and not with doctrinaire belief, "We proceed according to the rules of Bacon. . . . The facts. We will make our experiments and then the experiments will tell what it is."[21] (page 7)

费米学派>>>

- 什么是费米学派？见仁见智

From his adolescence onward, Fermi had a quite definite, positivistic view of the world, although it is doubtful that he would have accepted this or any other conventional label for his philosophy. He had not been raised in a religious environment, and so did not have to pass through a religious crisis, as many Italians do when they reach the age of autonomous thinking. As a matter of fact, philosophical discussions did not interest him very much, and even the development of scientific philosophy that occurred during the years of his maturity, through the activity of the Vienna circle and other groups, seems to have left him rather indifferent. This was perhaps because many of the fundamental ideas of logical positivism were already deeply rooted in his mind as self-evident truths, and because philosophical subtleties and polemics did not appeal to his taste.[22]

(page 7)

费米学派>>>

- 什么是费米学派？见仁见智

Possibly the most important part, however, of this pragmatic style was Fermi's ability to choose the right moment, the exact time when the state of knowledge and experimental capabilities matched the opportunity as it opened up.[23] Fermi's ability to perceive, before anyone around him could tell him, that relativity and quantum theory were the correct areas for future work in physics, marked the very beginning of his career. His ability to perceive the opening of a major opportunity in a new field, to detect and shift to the advancing frontier—rather than to wrestle with some "crisis" in existing conceptual structures—characterised his career throughout. (page 7-8)

费米学派>>>

- 什么是费米学派？见仁见智

费米的科学风格

费米的科学风格可能是他的意大利小组成功的关键。这一方面指的是费米个性与经历之间的融合，另一方面迎合了在当时世界科学发展状态下的科研机构中物理的机会与需求。

费米的特长和个性：整理、区分主次、理顺、简单假设、反例、即兴而起的数值解与近似，不管什么美学、哲学、形而上学的原理之类，只要简约。费米不像玻尔那样讲究这个那个的，他属于现实主义的做法。

费米学派>>>

- 什么是费米学派？见仁见智

费米的科学风格

费米不是宗教家庭长大的，因此对于宗教或哲学都不同感兴趣。而逻辑学的实证主义在他的心中早已根深蒂固、不言自明，而哲学理论与争议不合他的口味。

也许，费米实用主义的科学风格中最重要的是在理论和实验发展到了风口之后、他选择恰当时机的能力。例如他在周围任何其他人告诉他相对论和量子力学代表物理未来而很快就着手工作、他感受新领域重大机会的能力(而不是去纠缠现有概念的“危机”之类)。

费米学派>>>

- 什么是费米学派？见仁见智

Choice of Problem and Method of Research

A cool assessment of the situation showed him by the end of the 1920s that the vigorous development of quantum mechanics "signaled the completion of atomic physics". (page 8)

In a field advancing as rapidly as physics, it is now not at all unusual for a group of collaborating scientists to note that they may be overtaken by events, and to decide to explore a more promising field. But rarely if ever in the history of modern physics was an entry into a new field made in so pragmatic, unsentimental, well-phased and ultimately successful a way.[28] The decision of Fermi and his collaborators to change to nuclear physics out of all possible new fields was full of risks and would require great labour from everyone, since there was no experimental or theoretical background available to them—except in Fermi's own case, for example by his study of Rutherford's work on the artificial disintegration of nuclei, referred to above, and of the influence of the magnetic moment of the nucleus on the hyperfine structure of spectra, published in 1930. (page 9)

费米学派>>>

- 什么是费米学派？见仁见智

Segrè recalled: (page 8)

But already at Los Alamos [during the Second World War. G. H.] Fermi had the feeling that his next phase of activity would not be in neutrons but in something new, and he reminded me that just as [in the early 1930s. G.H.] he discarded all his investments in spectroscopy to go to nuclear work, so now he would leave the slow neutron in order to proceed to new conquests in the field of high-energy physics. In a half-joking mode he quoted Mussolini: "Rinnovarsi o perire—to renew oneself or to perish." [24]

This brings us directly to the circumstances under which the Fermi group in Rome, after its formation, turned its attention to the work in nuclear physics which ultimately gave it its pre-eminence and which led to the events of 1934.

费米学派>>> • 什么是费米学派？见仁见智

There were less than five years between the time when Fermi's group decided to enter the field of nuclear physics as novices and the time when this decision was carried out and achieved its results. Within this period, the major creative work took place during a few feverish months in 1934, and the group began to break up late in 1935.[29] During the period from late in 1929 to late in 1934, the sequence of events proceeded in a series of eight steps, all of which were, in retrospect, evidently necessary for achieving the goal. (page 9)

Corbino named Fermi as the person to play a dominant role. The talk was "in fact written certainly with intimate collaboration with Fermi".[31] (page 10)

At any rate, "One can therefore conclude that while great progress in experimental physics in its ordinary domain is unlikely, many possibilities are open in attacking the atomic nucleus. This is the most attractive field for future physicists."[40] (page 10)

费米学派>>> • 什么是费米学派？见仁见智

Third, the group had to remain scientifically alive and visible, and hence to publish, even during the transition period while shifting from atomic and molecular physics to nuclear physics.

During the same period, Fermi began his self-education in constructing instruments for research in nuclear physics.

make use of the "do it yourself" methods that were characteristic of him, both in theoretical and in experimental work. In order to minimize shop work and build a cloud chamber with his own hands, aided only by the most elementary tools, he first inspected several hardware stores and bought assorted kitchenware and gas plumbing.[45] (page 11)

But by the spring of 1931, Fermi had to give up the project, and go back to theoretical work. It must have been a sobering experience, and may have contributed to the decision that members of the group would have to go abroad to learn techniques at established centres of research in nuclear physics. (page 12)

费米学派>>> • 什么是费米学派？见仁见智

The next step may have seemed a rather brazen one. Before any significant work had yet been done by the Rome group in the field of nuclear physics, an International Congress on Nuclear Physics, organised by Fermi and sponsored by the Reale Accademia d'Italia, was held in Rome in October 1931. It was the first full-scale international conference

(page 12-13)

By the autumn of 1932, Fermi and Rasetti were ready to pursue in earnest "a joint program of research in nuclear physics in Rome".[49] The research budget of the department had been raised to between $2,000 and $3,000 per year: "a fabulous wealth when one considers that the average for physics departments in Italian universities was about one tenth of that amount".[50] A large and excellent cloud chamber was designed, and constructed by a private firm of mechanics, as was a gamma-ray crystal spectrometer. The group tried its hand at making Geiger-Müller counters,

费米学派>>>

- 什么是费米学派？见仁见智

In other laboratories, the situation was not a great deal better.

As the experimental facilities at Rome were being built up, the expectations for the right phenomenon coming along heightened. It was as if the group were poised for the moment (page 13)

The *annus mirabilis* in nuclear experimental physics was 1932

Chadwick's great discovery which had been missed by the Joliot-Curies, had been recognised by E. Majorana in Rome in the Joliot-Curie experiments; despite urging, he himself had not published nor taken seriously enough these ideas.

费米学派>>> • 什么是费米学派？见仁见智

In the same year, the cyclotron of E. O. Lawrence began to operate, ushering in the era of nuclear reactions by means of particle beams under the experimenter's control.

These successes at established centres might have discouraged other nuclear "beginners", and the continuation of the confused state of the theory of the nucleus during the early 1930s might have reinforced a feeling of discouragement in an ordinary group.[56] But Fermi at that very point demonstrated his mastery of theory with the completion in 1933 of his paper on the theory of beta decay. V. Weisskopf later called it "a fantastic paper, which I think stands out as a monument to Fermi's intuition . . . Beta decay, with Fermi's idea, stands apart from the rest of nuclear physics because it is the creation of particles."[57]

(page 14)

The approach and results of Fermi's beta-decay theory were sufficiently novel for the manuscript to be rejected by the editor of the journal *Nature*

费米学派>>> • 什么是费米学派？见仁见智

The idea for exploiting the new effect in a new way was, as one might expect, Fermi's. The Joliot-Curies had produced their artificial radio-activity by using alpha particles as projectiles. Fermi however said "that obviously should be done with neutrons. Neutrons should be much better."[62] The means were already on their bench. (page 15)

It is essential to remember that Fermi's suggestion would elsewhere have been dismissed as unlikely at best and absurd at worst. Professor O. R. Frisch has said:

I remember that my reaction and probably that of many others was that Fermi's was really a silly experiment because neutrons were much fewer than alpha particles. What that simple argument overlooked of course was that they are very much more effective. Neutrons are not slowed down by electrons, and they are not repelled by the Coulomb field of nuclei.[64]

费米学派>>> • 什么是费米学派？见仁见智

small group. Fermi's laboratory, on the other hand, now organised itself to focus all forces on one project and to concentrate all its expertise in one major effort, once that was identified as the area which would bring the maximum result for the laboratory as a whole.[67] The change here was from a wide-ranging group of subgroups to a group acting as a "team". It was an institutional innovation.

Fermi himself was intellectually at the centre of the group. (page 16)

Early in 1934, the first fruit of the Italian attack on nuclei with neutrons was the discovery of artificial radioactivity in fluorine and aluminium. This was published in March 1934 under Fermi's name.[71] In rapid succession, 40 of the 60 elements the group irradiated revealed the existence of at least one new radioactive isotope. A new one was found every few days; the members of the group looked back later to this as the most glorious and satisfying part of their lives.

Publication after publication followed rapidly. Almost casually, two institutional "inventions" were made at that point. One was multiple authorship: after the first two papers by Fermi alone, he drew in the rest of the group, and as many as six authors appeared under the title of the publications—an unusually high number at the time.

(page 17)

费米学派>>>

- 什么是费米学派？见仁见智

Another "invention" was the preparation and mailing out—to a list of about 40 prominent physicists around the world—of what now are called "preprints" of articles in press at *Ricerca Scientifica*.[72] In this way—improving even on the journal's remarkably fast publication process of about two weeks—Fermi's group could make its discoveries known in printed form within days of the work being finished, and could send the preprints to active nuclear physicists who might not have access in their own libraries to the journal itself. Amaldi remarks: "This procedure was facilitated by the fact that my wife Ginestra was working at that time at the *Ricerca Scientifica*."[73]

(page 17)

费米学派>>> • 什么是费米学派？见仁见智

The discovery of the existence and effectiveness of *slow* neutrons followed in about six months. In a sense, it was only a matter of time before the Italian group came upon it, but between their discovery of the effectiveness of neutrons in causing radioactivity in fluorine as the first instance, and the determination that slowed-down, i.e., moderated, neutrons can produce vastly increased and quite different activities, everyone seems to have thought that the more energetic the neutrons, the greater would be their effectiveness, that slow neutrons would have only a small capture cross section. All excitation curves known at the time for reactions produced by protons, deuterons, and alpha particles showed a rapid decrease with decreasing velocity of the particle inducing the reaction.[76] This was a consequence not so much of orthodoxy as of the deficient state of an incomplete theory; the effect of photomagnetic capture on the total capture cross section for neutrons was not yet known.

(page 18)

费米学派>>>

- 什么是费米学派？见仁见智

And yet, partly by his own work a year-and-a-half earlier on the paper which dealt with the effect of slow electrons, Fermi may well have been pondering the possibilities for slow neutrons, and at the very least was sensitive to clues on this point. When the "mythological event" did take place in October 1934, it took him very little time to develop the correct beginnings of a theory for the role slow neutrons play in activation. He and his group thereby entered into what has been called a heroic pioneering period of startling results which served, within a period of a few months, to reinforce and vastly strengthen the position this group had already achieved in physics. Not only was physics changed thereby. Scientifically, Italy had indeed regained "with honour its lost eminence", as Senator Corbino had hoped. And world history itself had been turned in a new direction.

(page 18-19)

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

费米经过评估，认为量子力学建立后原子光谱问题原则上已经解决。而像物理学科一样高速发展的学科，那时确实可以说新事物一件接着一件，有些眼花缭乱。因此，一个研究组选择一个有希望的学科方向是自然的。 **费米的进军核物理决定需要每个人付出极大努力、也有很大风险，因为当时没有实验和理论的背景**(除了费米在卢瑟福实验室做过原子核的人工裂解以及1930年发表的光谱超精细结构与原子核磁矩有关)。**这也是费米不断求新的特点。**

从1929年开始确定要做核物理到1934年取得重大突破这接近5年时间中(1935年研究组开始解体)，当时的整体计划是分为八个必要的步骤。当然，费米研究组实际上没有很好地按照规划走。

费米学派>>>

- 什么是费米学派？见仁见智

费米的科学风格

（塞格雷）在洛斯阿拉莫斯时期，费米预感到中子不再是下一个时期最新的东西了，而是其他新东西；就像他从光谱学转到核物理一样，他要从慢中子相关的事情转到高能物理方面。

“要么转向新事物、要么灭亡”

→ 永远向前看、走向时代的浪尖上去！

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

首先整体规划是在科尔比诺这样大人物的指导下做的，而科尔比诺指定费米作为主要负责人；实际上科尔比诺那篇令人鼓舞的报告是和费米两个人一起写的，在报告中甚至提到了应该建造加速器，大赞原子核物理的前景。

作为规划后的下一步，要做的是一些验证性的实验，检查设备、研习核物理基础。第三步是做一些大家看得见的进展，例如开始发表一些核物理理论。

费米从1930-1933年发表了20多篇论文(非核物理方向)，直到1933年才有第一篇核物理论文，虽然从1929年开始他就集中精力做核物理研究。他和同事自力更生建造一些用于核物理实验的小仪器。而在1931年，他又不得不暂时放弃计划，做一些理论工作；他要送一些人到核物理比较成熟的地方学习核物理技术。那段时间他可能比较难受。

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

第五步属于平台期，他们研究组还没有什么成绩。1931年10月他们主办了核物理国际会议，来了很多活跃的学者们。 这个会议是一种宣示，说费米研究组也要干核物理了。到了1932年秋天，每年的运行费提高到2000-3000 USD, 而那时一个物理学平均运行费只有十分之一左右。他们手里有了一些东西：大型高质量的云室、gamma 谱仪、盖格计数器等，还测量了一些gamma 射线能量。实验条件已相当不错。当然那时候核物理发展还处于襁褓期，前景有很大不确定性。1932年查德威克发现中子标志着核物理时代的开始。大家都知道约里奥-居里夫妇错失了这一发现，而那时**在罗马的马拉约纳(Majorana) 已经完整地认识到了**！只是他没有发表这个结果。与此同时，美国、英国实验室相继做出了加速器。

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

其他实验室条件的巨大进步可能令新研究组感到无助，新的实验结果令人困惑也让人摸不着头脑。但是费米在1933年突然发表了他的核物理理论杰作：beta 衰变理论。这篇文章确实很新奇，Nature 期刊很干脆地拒稿了。于是费米就把它刊登在意大利自己的期刊上了。1934年约里奥-居里实现人工放射性，消息在1934年2月传到罗马的费米研究组。大家都很兴奋，畅想未来。约里奥居里夫妇用的是alpha 粒子做入射炮弹，**费米说：更好的入射炮弹应该显然是中子，而他们具备了这一条件。**

我们必须说，**费米这一提议今天看起来比较合理，而换作其他实验室当时则很容易被否决或忽略，这是当时所有其他人第一反应，因为中子比alpha 粒子要少很多。**实际上这种想法忽略了中子比alpha 粒子更加有效：它不带电，与电子不作用、与原子核没有排斥力!

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

他们顺利要到额外的 1000 USD, 寻找中子与各种原子核作用的效应。这时候费米研究组“集中兵力”的组织形式优点就出来了，这与其他实验室不同：那里有许多实验、每个实验只有几个人。**团队组织形式是制度方面的一个创新**，现在许多实验室都采用了这种形式。

费米是团队的中心，负责协调组织各个部分，还作为理论指导；过去许多实验的理论与实验是分离的，这种团队的做法后来被大家借鉴成为惯例。

1934年初，费米研究组第一批成果是中子轰击氟和铝产生新的放射性核素，随后他们做了40种元素，几乎每隔几天就发现一次新的人工放射性核素。团队成员回忆说：这也是他们这辈子最满意、最高光的时期。论文很快出来了。前两篇是费米的，其他有合作者、最多有6个作者，**这也是当时作者最多的记录**。

费米学派>>>

- 什么是费米学派？见仁见智

问题的选择和研究方法

他们另一项创新是预印本方式：他们把寄给期刊的论文、未发表前做成印刷品立即送给当时四十位著名学者们。他们可以在工作完成几天内就可以做好预印本。当时阿马尔迪的妻子就在期刊部，还可以走后门式地做得更快。这个做法反响很好。

“慢中子技术”的发现是在半年（1934年10月)之后，不过这可能也是迟早的事情。传统上大家认为快中子更有效，而慢中子效率低下；这是过去经验和相关实验中看到的。费米过去可能考虑过这种可能性，所以当看到结果之后几乎不假思索地理解了这种立即引起轰动的现象。这不仅极大提升了费米研究组的地位，不仅改变了物理学，也使意大利再创辉煌，甚至世界历史也由此拉开转向的序幕。

费米学派>>>

- 什么是费米学派？见仁见智

Fitting into a Tradition

Fermi's mastery of physics and his style of research may not have been enough in themselves to produce the transformation of physics in Italy. With these characteristics alone he still might have had the same fate as Amedeo Avogadro, the first holder of a chair in theoretical physics in Italy (*fisica sublime*), whose contributions to chemistry are, of course, very well known, but who neither received adequate recognition in his time nor formed a school. From the beginning Fermi understood the tradition within which science was carried on in Italy and took good advantage of the system which existed for the institutionalisation and professionalisation of science. "Fermi was fully aware of the system and was eager to reach the top as fast as possible."[77] So when, on returning from Leiden,

费米学派>>> • 什么是费米学派？见仁见智

Fermi "looked eagerly for a job", he undertook to advance his career through a substantial number of publications. Thus he wrote (in Italian) as many papers as he could. Although he kept his standards high, it is clear that he counted them carefully and felt satisfaction in seeing the pile of his reprints mount ever higher. He wanted to reach the next step in the academic career, the *libera docenza*, as rapidly as possible, and he believed that the sheer number of publications was important—especially if the judges should be too lazy, or unable, to assess the value of his contributions.[78]

(page 19)

An interesting aspect of Fermi's sensitivity to the tradition and to the existing opportunities within the tradition was his ability, in an early and crucial stage of his career, to seek out and respond to mathematicians, and to obtain support and patronage from that group. Fermi had studied mathematics, even with passion, but chiefly because he considered it necessary to the study of physics, "to which I want to dedicate myself exclusively", as he explained to his first mentor, Adolfo Amidei, in 1918.[79]

given them by the press and public. It is not without significance that the only Nobel prize in physics awarded to an Italian before Fermi's in 1938 was the prize—half share—for 1909 to G. Marconi for radiotelegraphy—and that, if anything, was something of an embarrassment to many Italians, since he had not found support in Italy.

in 1918 he found that he already knew most of the subjects which were being taught, that he had to learn modern physics on his own, and that there were only two other students in physics—Franco Rasetti and Nello Carrara.

The state of excellence in mathematics in Italy at the time, as indicated by such names as Cremona, Peano, Severi, Volterra, Enriques, Ricci-Curbastro, Levi-Civita, and Castelnuovo, was indeed high. These men had

费米学派>>>

- 什么是费米学派？见仁见智

对于传统的适应

费米的研究能力和个人风格并不足以对意大利物理学产生转变。如果只有那些特点的话，费米命运估计就像阿米德奥-阿弗伽罗德一样，虽然他对于化学的贡献很有名、但是在当时没有得到恰当的认可，也没有形成什么学派。费米一开始就指导意大利科学界内的传统，很在意、很急切地尽快走到最高职位。他尽可能多地发表论文。他看着论文目录越来越长，他坚信那些评委们谁也懒得看那些论文的细节和价值，单纯的数量就很有分量。

费米对于意大利学界传统敏感的一个侧面是他对于数学家的亲近态度、并从他们那里得到支持。在费米之前、1909年伏达获得过诺贝尔物理奖（有过争议）；1918年他已经意识到，在物理方面没有人可以教他什么，而且他也只有两个同学。那时意大利数学还很好。

费米学派>>> • 什么是费米学派？见仁见智

Dealing with Academic Politics and National Ambition

Fermi's ability to use opportunities offered by academic politics and by current nationalistic ambitions was also of some significance. It is commonly held that Fermi was deeply apolitical. But this estimate cannot apply to the politics of university life on which, for better or worse, depended the creation and maintenance of a new and relatively costly establishment such as Fermi's group.

(page 20)

It is not difficult to see that on encountering the evident genius of Fermi within this framework of his own preoccupation, Corbino, the politician, entered into a state of symbiotic collaboration with Fermi, the scientist; this was not less effective for being probably largely unconscious. It was as a result of Corbino's efforts that, despite the essentially rigid structure of the Italian university, a chair in theoretical physics was created at the University of Rome, and in such a way that it could be filled only by Fermi. Soon thereafter, again through Corbino's influence, Fermi became the only physicist elected to the Royal Academy of Italy, at the age of 28.[87] Similarly, Corbino was the moving force behind the administrative actions necessary to obtain appointments and funds for every one of the members of Fermi's circle, including the creation of yet another chair in physics, in 1930, for Rasetti [88]—in spectroscopy, at precisely the time when Rasetti was leaving spectroscopy and going into nuclear physics.

(page 22)

费米学派>>> • 什么是费米学派？见仁见智

as a result of Corbino's efforts that, despite the essentially rigid structure of the Italian university, a chair in theoretical physics was created at the University of Rome, and in such a way that it could be filled only by Fermi. Soon thereafter, again through Corbino's influence, Fermi became the only physicist elected to the Royal Academy of Italy, at the age of 28.[87] Similarly, Corbino was the moving force behind the administrative actions necessary to obtain appointments and funds for every one of the members of Fermi's circle, including the creation of yet another chair in physics, in 1930, for Rasetti [88]—in spectroscopy, at precisely the time when Rasetti was leaving spectroscopy and going into nuclear physics.

费米学派>>> • 什么是费米学派？见仁见智

protected operation. Without this protection it is almost inconceivable that young Fermi could have weathered the opposition from such hostile forces as the other professor of physics at Rome, Lo Surdo, and from other established persons who, for many years, did not look kindly upon Fermi's growing activities. For Fermi, Corbino was a godsend not only as a protector but also as administrator—just as Fermi later had George Pegram as a sympathetic administrator at Columbia, Arthur H. Compton at the Metallurgical Laboratory at Chicago, and Samuel Allison at the University of Chicago. The appointment of Lo Surdo as director of the Physics Laboratory after the death of Corbino in January 1937 signalled danger to the institutionally fragile group, and may have had an effect in turning Fermi's thoughts more strongly to emigration.

(page 22)

费米学派>>> • 什么是费米学派？见仁见智

Corbino's influence on the growth and activities of the Fermi group is everywhere evident—for example, in the change of direction of the group's work as indicated in his speech of 1929, and on such occasions as his opening speech in 1931 at the Rome Conference of Nuclear Physics or his talk at the royal session of the Accademia dei Lincei in 1934. Often he spoke at the risk of offending other interests; thus Segrè recalls that Corbino "was jumped on terrifically by all the physicists in Italy"—except for Fermi's collaborators—after his speech in 1929.

Corbino even busied himself with drawing students' attention to Fermi at a time when there were almost no students in physics at the University of Rome. As Amaldi recalls:

> He started to make propaganda. . . . For instance, in my case, I was Corbino's student in my second year. . . . Then he stopped five minutes before the end [of his lecture] and said: "Now some of you should stop your study of engineering and you should go into physics, because we now have a new professor of physics here in Rome. . . . I can assure you that this is the man who can bring physics to a high level in Italy. In this moment, the young people should go into physics".[89]

(page 23)

tion for the Advancement of Science. One experienced observer has gone so far as to say that "Fermi would have been almost impossible in Italy without Mussolini".[94] But whatever the character of a regime, if it was desirous of supporting science, it would have had to invent some way of dealing with Fermi, given the absence of a clear tradition for his sub-speciality.

On the other hand, there was a long tradition in Italy of having scientists drawn into the councils of government, which resulted in a freer and more natural association of political leaders with Italian scientists and scholars than was the case in many other Western countries.[96] The line leading from Blaserna to Corbino and then to Fermi was only one example of such cases.

费米学派>>>

- 什么是费米学派？见仁见智

学术政治与国家的理想

费米利用学术政治和国民理想的能力是很重要的方面。一般都认为费米很不喜欢涉足政治方面的事情，但是不管如何，不能不说费米研究组的建立和运行需要较多的经费支持，而这些离不开大学生活中的政治。**费米毕业后回到罗马立刻就去找科尔比诺，很快在心理上成为他的小学生。科尔比诺为费米在罗马大学设置了理论物理教授的职位、在费米28岁时入选皇家科学院、为费米研究组每一个人找位置和资助等，从而把整个研究组都保护起来了。**

假如没有这些保护，年轻的费米早就凋零了；那时有许多对费米充满敌意的教授。科尔比诺不仅是保护者、也是经营者。科尔比诺去世后，**他的政敌上台是费米决心移民的一个重要原因**。科尔比诺的影响在费米组内几乎无处不在，他在课堂上为费米组做各种招人广告。

“**没有墨索里尼，就没有后来的费米**”。意大利学者去从政的比例 比其他国家都多。

费米学派>>>

- 什么是费米学派？见仁见智

The Internationality of Fermi's Group

Charles Weiner has coined the useful term "the travelling seminar" to describe the lively interaction of European and American physicists in the 1920s and 1930s, even before the exodus from German universities as the result of the rise of Nazism.[100] Scientists, and particularly physicists, had developed to a remarkable degree a sense of being engaged in an international undertaking. (page 27)

Fermi seems to have understood the international character of physics from the beginning. For example, he undertook the study of languages for this reason. Amidei recalls: "I advised him [about 1917]—and he immediately followed my suggestion—to study the German language, because I foresaw that it would be very useful for reading scientific publications in German without having to wait until they were translated into French or Italian".[104] His own trips to Göttingen, Leiden, Copenhagen, and the United States at early stages of his career helped to express and reinforce that sense of belonging to an international community of physicists—a community in which Italy still had to make its way. (page 28)

and using the internationality of science. One was travelling abroad, if necessary with a fellowship such as one from the Rockefeller Foundation or from the Italian government, in order to learn techniques and to obtain speedy publication abroad—this was part of the reason for the trip of Segrè and Amaldi to Rutherford's laboratory in the summer of 1934. There

A second institutional mode consisted of the attendance at and the conduct of international conferences, starting from that in 1927 at Como, and including the conference on nuclear physics in Rome in 1931. For the latter the funds had come from Italian industry, and the ubiquitous Corbino had presided over the negotiations for the grant. Many of those

A third mode was the provision of hospitality in Rome to visitors from other countries. Segrè recalls: "We had had a tremendous number of visitors who had brought in a lot of life. We had had Bethe, Bloch, Peierls, London, Feenberg [and Placzek and Bhabha. G.H.]. By 'visitor' I mean someone who spent some time really and participated in the life of the place [rather than someone who came just for a day, as Raman and many

费米学派>>>

- 什么是费米学派？见仁见智

It is, however, significant that despite all these visitors, the group in Rome differed fundamentally from most other major physics centres in so far as there was no place in it for long-term participants from other nations. Unlike the situation in London, Cambridge, Paris, Copenhagen, Hamburg or Berlin, Rome was not a physicist's " league of nations ". (page 29)

The fourth feature of the institutional internationality of science is publication abroad and the sending of preprints to a list of colleagues in many countries. The policy of Fermi's group as to publication was carefully balanced to include publication in foreign, as well as in Italian, languages and journals. Only when great speed of publication became essential in 1934 during the period of the rapid growth of the list of newly identified radioactive isotopes, was publication undertaken in *Ricerca Scientifica*, where there was no " refereeing " to delay publication and where preprints were made available very promptly for distribution abroad. (page 29)

费米学派>>> • 什么是费米学派？见仁见智

(page 29)

Apart from these four modes there was pressure owing to the incentive to realise Corbino's—and others'—hope of placing physics in Italy in a prominent position on the world map of science. It may have been partly for this reason that, apart from collaborating with short-term visitors from abroad, the Fermi group chose to remain a purely Italian group.

once the Italian group had chosen to enter into international competition for recognition as a major centre for nuclear physics—itself a decision prompted not by a "crisis" but by the feeling that the earlier fields of physics and expertise were becoming exhausted and therefore boring—the chief sense of crisis was the threat of missing the main chance, or of being beaten to it. As it turned out, this unspoken pressure, which the Italians had put on themselves, paid off magnificently, not only for science in Italy, but, by the very nature of science, for science everywhere.

(page 29-30)

费米学派>>>

- 什么是费米学派？见仁见智

研究组的国际化

在二十年代和三十年代，驱逐犹太运动之前欧美物理学界的那种活跃交流当时出现了一个新词汇“旅行报告”。例如在1930年前后，卡文迪许实验室的来访者川流不息，有些人仅来两三天给一个报告，有些人待两三年拿一个学位。

费米似乎一开始就意识到物理学的国际属性，例如他学习外语。阿米代伊建议他直接阅读原文而不是等着翻译 …… 他早年访问德、荷、美就可以使用外语。国际旅行访问、主办参加国际会议、接待国外访问者[但是这里没有地方提供给来自国外的长期访客]、给国际专家群邮寄论文和预印本。费米研究组的论文既有意大利语、也有发表在国外的。

但是，来自国外竞争压力以及为意大利荣誉，与国外合作都是短期的，研究组全是意大利人。

国际竞赛中“赛道选择”：新领域、不做老问题的危机

科莫国际会议方面的乌龙……

1927年在意大利科莫举行了科莫会议，除了爱因斯坦、薛定谔和狄拉克以外，当代最著名了物理学家，包括玻尔、海森堡、普朗克、洛伦兹、德布罗意等都出席了。但是玻色却没有能够出席，原因很离奇。因为当时大会向远在印度的玻色教授发出了邀请函，寄往了加尔各答大学，署名“寄给加尔各答大学的玻色教授”。但是当时玻色已经离开加尔各答大学去了达卡大学，而加尔各答大学还有一位姓玻色，全名叫做D.M.玻色的教授，而当时的通讯并不如现在发达，于是这位名不见经传的玻色就代替了当时已经很有名望的S.N.玻色，参加了众星云集的科莫大会。

费米学派>>>

- 什么是费米学派？见仁见智

Social Organisation of the Group's Activity

Isolation and Protection: The group's relative isolation and protection from outside effects was striking and owed much to Corbino as an administrator and politician.

(page 30)

There was another benefit the group derived from its isolation and its protected position. This was a period of great achievements and ebullience in physics; but at the same time the social, economic, and political conditions of Europe were in disorder. Not the least problem which anyone interested in or working on physics faced, in Italy as elsewhere, was that there were hardly any career expectations in the field, other than perhaps in secondary school teaching and to a very limited degree in the universities. Most of Fermi's associates had switched from engineering studies, which traditionally led to much more secure employment in Italy.

(page 31)

费米学派>>> • 什么是费米学派？见仁见智

Under Fermi, they settled for relatively poorly remunerated posts as assistants, and they continued to do that for a considerable time. Amaldi remarked later that they simply did not worry about this as a problem.[111] It probably helped that almost all in the group, excluding Fermi himself, came from professional families which were financially relatively comfortable. They lived modestly—and, in Amaldi's case, by supplementing his income through the income earned by his wife. Amaldi added:

> We were not interested at all in that period to make a quick career. I was not at all interested and this is more or less the general idea. We felt it was so nice what we were doing, so agreeable, so wonderful, that there was no reason to go away to get a better position. I remember this because on this we had very long discussions. One of us said, "Well, after all, what is the reason to get a better position, to go in a place where you don't work! Here it is so nice, this is the thing that we should do, this is where you live and work. . . ." We were so convinced that we were doing nice things.[112]

(page 31)

费米学派>>>

- 什么是费米学派？见仁见智

研究活动的社会组织构架

这个组织构架对于科研活动非常适宜、有效率，首先是与外界的区隔和保护方面，这是科尔比诺的功劳。科尔比诺保护费米、保护研究组的成员，使得年青的费米可以远离政治斗争。费米来自普通家庭，没有改天换地的理想。这种保护还有一个重要意义在于当时的社会风气和认知，意大利社会整体不在意物理学的新发展，学习物理最多去中学或极少地在大学教书，费米研究组的成员基本都来自于工程专业，这比物理在社会上吃香得多。

研究组 (除了费米之外)都来自于不错的家庭，因此虽然待遇低了一些，也没有什么麻烦。阿马尔迪说：我们几个在职业发展方面并不着急，我们几个人团结一致、很开心，因此没有想过更好的去处。我记得我们多次讨论过，有人说，去一个不喜欢的地方找一个好职位的理由安在？这里多好啊，做我们应该做的事情、这是我们该待的地方。我们都坚信我们在做很棒的事情。

费米学派>>>

- 什么是费米学派？见仁见智

Small and Flexible Group: More needs to be said now about the formation of Fermi's group, for it did not follow the lines of a well accepted model. In 1932, Frisch remarks, " In Europe there were few laboratories in which nuclear physics research was conducted, and I think the word ' team ' had not yet been introduced into scientific jargon. Science was still pursued by individual scientists who worked with only one or two students and assistants ".[115] By 1932, however, Fermi had already built up a group which, while small (by present standards), was agile, widely trained so as to be ready to pounce on the important problem, and willing to wait for it.

(page 31-32)

at Chicago, although not without grumbling. A small group of high quality seemed to fit his personality better. It was not his style either to build an institute in the manner which has since become fashionable, with a wide range of major facilities which others would come to use for their own research problems, or to build a teaching centre which would attract and train large numbers of students from near and far. He liked to invest his energy in a group which provided personal contact on physics problems which were of direct, current relevance to his research interest. The efficiency

(page 32)

depended. But it is also just this kind of "lucky break" which, if made in a large and busy laboratory, might well not have come to the attention of the person whose contribution is essential to change the observation from a bothersome irregularity—which indeed could have been easily removed, for example, by carrying on all observations on one table only—to a transforming discovery.

灵活的小分队：当时在欧洲核物理研究还没有“团队”这个词儿呢，一般的实验都是一个老师带着一两个学生或助手完成。然而在1932年，费米则建立了一个小(按现在标准)而精干的研究组随时准备做、也愿意做任何重要的事儿。

费米不喜欢大规模的研究所，而是喜欢在一个小团队里做老板，这样研究组里所有的事情乃至细节都可以亲自控制。而假如在一个大规模实验室里，新发现的那种征兆不一定引起注意，很容易忽略。

费米的那个“幸运发现”就属于这一类！

费米学派>>>

- 什么是费米学派？见仁见智

Cohesion by Recruitment: From the beginning, Fermi's group was different from any other known to me in the history of physics. It was characterised by a cohesion which stemmed from an extraordinary history of recruitment and apprenticeship. Fermi, of course, had offered himself for, or at least consented to, "recruitment" by Corbino, and after arriving in Rome in 1926, Fermi, with Corbino's support, proceeded to recruit a group of half a dozen crucial collaborators. Rasetti, a schoolmate and friend of long standing, an ex-engineering student at Pisa, was brought in as Corbino's assistant (*aiuto*). Rasetti has described his earlier intellectual recruitment by Fermi

(page 34)

招聘和师生友谊而来的凝聚力：这与欧洲其他研究中心差别很大，如卡文迪许实验室的人来自英、澳、美、苏。

费米学派>>> • 什么是费米学派？见仁见智

Family-Enterprise Model: Fermi himself had come from a closely-knit family, and was very attached to his brother and his sister. His own fate was determined decisively by the decision of a colleague of his father, Adolfo Amidei, intellectually to "adopt" Fermi at the age of 13. He had here a model not too different from that of the way Segrè and Amaldi were adopted by Fermi.[126]

(page 35)

We may think of Fermi as the centre of a set of planetoids, representing the students and collaborators whom he had recruited, Fermi himself having a position like that of Jupiter surrounded by its moons. The Rome group preferred a different model—the light-hearted analogy with the ecclesiastical hierarchy, in which Fermi's central position was indicated by his nickname "il Papa", because of his infallibility in quantum physics.

费米学派>>>

- 什么是费米学派？见仁见智

(page 36)

This whole system, however, itself rotated about the centre of that universe—Corbino, acting as the sun. If Corbino was not the father—the Rome group did refer to him as " Padre Eterno " or " Padreterno " [127]—he was at least the godfather. He was always at hand, dropping in to talk, participating in seminars and important decisions. In fact he was living with his family in the same building, one floor above the Physics Institute of which he was the director. Laura Fermi reports that Fermi and his colleagues were called, appropriately, " Corbino's boys ". The usual auto-

费米学派>>>

- 什么是费米学派？见仁见智

家族式管理模式：费米自己与家庭联系密切，他的命运改变也是因为父亲的同事阿米代伊建议、安排的。

费米在研究组里是中心和领袖，就像周围有许多卫星的木星一样，或者像教会组织里的“教皇”一样（在量子物理方面从不犯错）。而整个系统则是围绕科尔比诺的[全能神(有能力让奇迹上演)]，像太阳系中的太阳。

费米学派>>> • 什么是费米学派？见仁见智

(page 36)

Frugality and Improvisation: Superb use was made of relatively small funds, and of improvisation wherever necessary. Not only were the salaries very low, but so was support for the laboratory's research, considering its enormous output and success. The lack of a good shop and of an adequate machinist was a great handicap. In the early 1930s the Rome group thought about, but—despite Corbino's hint in 1929 that frontier work would require an accelerator—was never able to build a cyclotron.[130] Segrè reports: "You see, it was a different type of physics. It was done on a few tables with string and sealing wax. It was extremely simple. It cost very little." To be sure, it was not very different elsewhere. Rutherford's laboratory had perhaps 10 times as large a budget, but that was still little.

节约与财务应急：财务方面，每分钱都用到了刀刃上，不过必要时也能有应急资金。与取得的成就相比，工资很低、实验室的资助也不足。许多东西买不到，也找不到机械价格的地方，这些极大阻碍工作的开展。研究组在30年代曾梦想过、甚至科尔比诺也在1929年提到过核物理前沿研究需要加速器，但是那时从未实施。

塞格雷说：“你看看，那是不同的物理学啊，物理是在几个桌子上做的，上面几条线和封蜡，极为简陋、不花什么钱的。当然，其他地方也好不了多少，卢瑟福实验室比我们多十倍，但也是杯水车薪。”

费米学派>>> • 什么是费米学派？见仁见智

(page 38)

Concluding Observations

In sum, Fermi's group helped physics in Italy to "come of age" in the 1930s, by all the usual criteria; in terms of support—financial and institutional—recruitment, opportunities for careers, and national and international recognition. This was achieved by a group unlike any other we know of in physics before that time: a group which modelled itself to a large degree on a family; had internal and external aspirations, one of which was to bring honour to Italy through the work of the Italian scientists; tried to operate within a tradition—though this does not mean archaic—using available institutions but on occasion making institutional innovations; was essentially a small-scale operation; and was politically and economically a protected operation.

费米学派>>> • 什么是费米学派？见仁见智

该文的总结：费米当年在意大利的研究组帮助意大利的物理在三十年代完成了成年礼，这个成年指的是按照所有标准来说的，如财务和制度方面的支持，包括招聘、职业机会、国内外的认可。而这一切都是一个与历史上任何研究组都不同的方式取得的。

这个小组的样子有点像家族式，有着来自内部和外部的热情和抱负，其中一个抱负是意大利学者为意大利争光。这个小组的运行使用现有机构、遵循当地传统但是也有制度方面的创新。研究组规模不大，在政治和财务有一定保障。

费米学派>>>

- 什么是费米学派？见仁见智**【该文的总结】**

据说, 费米直接带的学生诺贝尔奖获得者最多(不包括隔代的获奖者)

费米的风格独特: 现实主义、简约;

实验技术水平-理论洞察力-广博知识-简约模式之间的微妙平衡

费米的特长和个性：整理、区分主次、理顺、简单假设、反例、即兴而起的数值解与近似，不管什么美学、哲学、形而上学的原理之类(只要简约)。

• 什么是费米学派？见仁见智

说明:

因为时间关系，费米在美国期间指导学生的资料似乎还不够，材料不少、但是比较零散，全面系统的总结没有见到。我在私下与几位年长的老师讨论，但不够系统、也没有查证，因此这里不敢草率行事。费米**在美国期间客观环境变化很大，而他指导学生成就更大，**这部分应该以后花力气去分析挖掘。

费米学派>>>

- 什么是费米学派？见仁见智

迄今为止培养诺奖学生最多

费米有三类学生：

理论家：李政道、杨振宁、**Sam Bard Treiman、Ettore Majorana、Marvin Leonard Goldberger、Mildred Dresselhaus、Geoffrey Foucar Chew**

实验家：*Jack Steinberger*、**Emilio Gino Segrè、Arthur Hinton Rosenfeld、Jerome Isaac Friedman、Owen Chamberlain、Edoardo Amaldi**

【再传弟子：Steven Weinberg、 David Gross】

理论&实验：Richard Lawrence Garwin、Harold Melvin Agnew

应该还有一个学生芝加哥大学获得诺贝尔物理奖[费米传, page 220]，**没有找到出处…… ……**:

“费米还有一项独一无二的记录令他鹤立鸡群，那就是他有6位芝加哥大学的学生外加一位罗马大学的学生都获得了诺贝尔物理奖”

营造他在意大利罗马“帕尼斯佩尔纳大道”的那种氛围，定期邀请高年级学生到他的办公室小聚。话题从黎曼几何到电路噪声，无所不包。大胆假设、小心求证，没有哪个公式是理所当然的。“物理学是从打地基开始、一砖一瓦、层层累积起来的。”他与学生在大条桌上进餐、热烈讨论，气氛随意，并延申到休闲娱乐的活动中。P220

费米学派>>>

- 什么是费米学派？见仁见智

对于“外面的”人、没有师承关系或明确合作者提供极大帮助。

例如：**钱德拉塞卡、盖尔曼、费曼、戴森(Freeman Dyson, 可你什么都没有)**、

泰勒、乌拉姆

塞格雷、杨振宁、Richard Garwin、泰勒、乌拉姆、盖尔曼、钱德拉等
[费米临终前曾去探望费米]

为什么那么多学生喜欢费米？

他脚踏实地、思想深刻、知识渊博、富有人格魅力。

他聪明+厚道，把(各种风格)优秀人才团结在周围、用心培养、锐意创新

短暂而曲折的人生、个人和集体的辉煌

费米学派>>>

- 什么是费米学派？见仁见智**【本次报告的总结】**

费米学生们都盛赞费米之伟大、费米之教导，说他待人包容宽厚、狡黠而不失厚道，大家都感激和喜欢他。费米的学生散布在基础科学、高科技、政治和文化交流多个领域，**每个人非常成功。**

费米的学生没有一个人在费米后面做那些补遗的事情，**都向前进！向前进也是费米最重要的科学特质**。

费米英年早逝---假如再给他20年寿命，那么今天物理学有所不同！！！

费米学派>>> • 什么是费米学派？ 【本次报告的总结】

费米培养的学生每个人风格迥异、都不像费米，也没有一个学生沿着费米过去的具体思路做事情。费米不仅本人是伟大的科学家，他更是一位伟大的教育家，他的学生风格和类型如此不同（甚至几乎不像一个导师的学生），而**他做到了有教无类，并且很好地挖掘到每个学生心灵上独特的、最亮的闪光点，让每一个心灵按照各自独特的方式发光。**他名下的每一位学生都在后来职业生涯中非常成功!

费米和在他指教下的学生和青年同事们之众(如果加上在不同时期受教于他的学者人数就更多了)，足以称之为Fermi school，**“有教无类、永远向前”**，可以费米在教育科研方面的风格所在。

谢谢大家！

致谢：

方在庆 研究员
中科院自然科学史研究所

李志宏研究员
中国原子能研究院

冯达旋
Univ. Texas at Dallas