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# Portrait of Enrico Fermi as a young scientist

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# Enrico Fermi as a student in Pisa (1918-1922)

- Born September 29, 1901 in Rome
- Enters the Scuola Normale Superiore as a winner of a national competition (November 1918)
- Physics chair: Luigi Puccianti (1875-1952): known spectroscopist, taught only classical physics (already known by Fermi)
- Enjoying lots of free time, Fermi studies General Relativity, (old) Quantum Theory, Atomic Physics and advanced Mathematics (tensor calculus).
- Puccianti asks him (still a student) to give lectures on Quantum Theory

# Fermi at the Scuola Normale



# Fermi's first papers (1921-1922)

- Intrigued by a possible contradiction between electromagnetic theory and general relativity concerning electromagnetic mass, publishes some papers: (still a student)
- “Sull'elettrostatica di un campo gravitazionale uniforme e sul peso delle masse elettromagnetiche”, *Nuovo Cimento* 22, 176-188 (1921).
- “Sulla dinamica di un sistema rigido di cariche elettriche in moto traslatorio”, *Nuovo Cimento* 22, 199-207 (1921).
- “Über einen Widerspruch zwischen der elektrodynamischen und der relativistischen Theorie der elektromagnetischen Masse”, *Physik. Zeitschrift* 23, 340-344 (1922).
- “Correzione di una grave discrepanza tra la teoria delle masse elettromagnetiche e la teoria della relatività. Inerzia e peso dell'elettricità”, *Rendiconti Accademia Lincei* 31, 184-187 (1922); *Rendiconti Accademia Lincei* 31, 306-309 (1922).
- In 1922 Fermi introduces the (later so-called) “Fermi coordinates” for General Relativity
- *Sopra i fenomeni che avvengono in vicinanza di una linea oraria*”, *Rendiconti Accademia Lincei* 31, 21-23, 51-52, 101-103 (1922).

# Fermi's thesis and dissertation (1922)

- Fermi is forced by general rules to discuss a thesis on experimental physics
- Puccianti addresses Fermi, Carrara and Rasetti to study X-rays
- Fermi graduates on July 4, 1922. According to his own judgment his thesis is “a first-class mess”
- In any case some of his results were soon published:
- “I raggi Röntgen”, *Nuovo Cimento* 24, 133-163 (1922).
- “Formazione di immagini coi raggi Röntgen”, *Nuovo Cimento* 25, 63-68 (1923).
- On July 7, 1922 Fermi obtains also his Diploma at the Scuola Normale, presenting a dissertation on probability theory: *Un teorema di calcolo delle probabilità ed alcune sue applicazioni*”,

# Fermi in Göttingen (1923)

- Fermi obtains from Corbino a six-month fellowship to be spent in Göttingen
- No real integration with the Born—Heisenberg-Jordan group
- Fermi applies analytical mechanics to open problems in quantum theory
- “Il principio delle adiabatiche ed i sistemi che non ammettono coordinate angolari”, *Nuovo Cimento* 25, 171-175 (1923).
- “Dimostrazione che in generale un sistema meccanico normale è quasi ergodico”, *Nuovo Cimento* 25, 267-269 (1923).
- “Alcuni teoremi di meccanica analitica importanti per la teoria dei quanti”, *Nuovo Cimento* 25, 271-285 (1923).
- “Generalizzazione del teorema di Poincaré sopra la non esistenza di integrali uniformi di un sistema di equazioni canoniche normali”, *Nuovo Cimento* 26, 105-113 (1923).
- “Sulla teoria statistica di Richardson dell’effetto fotoelettrico”, *Nuovo Cimento* 26, 97-104 (1923).
- “Sopra la teoria di Stern della costante assoluta dell’entropia di un gas perfetto monoatomico”, *Rendiconti Accademia Lincei* 32, 395-398 (1923).

# Back from Göttingen (1923-1924)

- Fermi's first important contributions to quantum statistics
- “Sulla probabilità degli stati quantici”, *Rendiconti Accademia Lincei* 32, 493- 495 (1923). “Über die Wahrscheinlichkeit der Quantenzustände”, *Zeitschrift für Physik* 26, 54-56 (1924).
- “Sopra la riflessione e la diffusione di risonanza”, *Rendiconti Accademia Lincei* 33, 90-93 (1924).
- “Considerazioni sulla quantizzazione dei sistemi che contengono degli elementi identici”, *Nuovo Cimento* 1, 145-152 (1924).

# Fermi in Leiden (1924)

- Thanks to Volterra he gets from the Rockefeller Foundation a new fellowship to be spent in Leiden at Ehrenfest's laboratory, and has a good scientific relationship with Ehrenfest.
- He meets Einstein and Lorentz, and gets Einstein's appreciation.
- Significant contributions in spectroscopy and atomic physics,
- “Berekeningen over de intensiteiten van spektraallijnen”, *Physica* 4, 340-343 (1924);  
“Sopra l'intensità delle righe multiple”, *Rendiconti Accademia Lincei* 1, 120-124 (1925).
- Fermi gets interested in collision processes (method of virtual quanta, not appreciated by Bohr)
- “Sulla teoria dell'urto fra atomi e corpuscoli elettrici”, *Rend. Accademia Lincei* 33 (1924) 243-245; *Nuovo Cimento* 2, 143-158 (1925).
- “Über die Theorie des Stosses zwischen Atomen und elektrisch geladenen Teilchen”, *Zeitschrift für Physik* 29, 315-327 (1924).



# Fermi in Florence (1924-1926)

- Thanks to Garbasso, Fermi e gets a (temporary) position in Florence as a lecturer in Mathematical Physics
- He meets there his old friend Rasetti and starts a fruitful collaboration on atomic physics and spectroscopy.
- Joint (experimental and theoretical) papers:
- “Effect of an Alternating Magnetic Field on the Polarisation of the Resonance Radiation of Mercury Vapour”, *Nature* 115, 764 (1925).
- “Über den Einfluss eines wechselnden magnetischen Feldes auf die Polarisation der Resonanzstrahlung”, *Zeitschrift für Physik* 33, 246-250 (1925).
- “Effetto di un campo magnetico alternato sopra la polarizzazione della luce di risonanza”, *Rendiconti Accademia Lincei* 1, 716-722 (1925).
- “Ancora dell’effetto di un campo magnetico alternato sopra la polarizzazione della luce di risonanza”, *Rendiconti Accademia Lincei* 2, 117-120 (1925).

# Quantum statistics (1925)

- Fermi does not like Heisenberg and Born's approach to quantum mechanics, and concentrates on quantum statistics.
- In December 1925 he writes his fundamental paper on statistics satisfying the exclusion principle (Fermi-Dirac statistics):
- “Sulla quantizzazione del gas perfetto monoatomico”, Rend. Accademia Lincei 3, 145-149 (1926).
- “Zur Quantelung des idealen einatomigen Gases”, Zeitschrift für Physik 36, 902-912 (1926).

# Competing for a chair (1925-1926)

- Lost competition for a permanent position in Florence (1925)
- Competition for a chair in Mathematical Physics in Cagliari: notwithstanding the favourable votes of Volterra and Levi-Civita, the chair is offered to (much older) G. Giorgi (1925)
- Corbino starts manoeuvring for the institution of a chair in Theoretical Physics in Rome
- (First chair in Theoretical Physics in Italy)

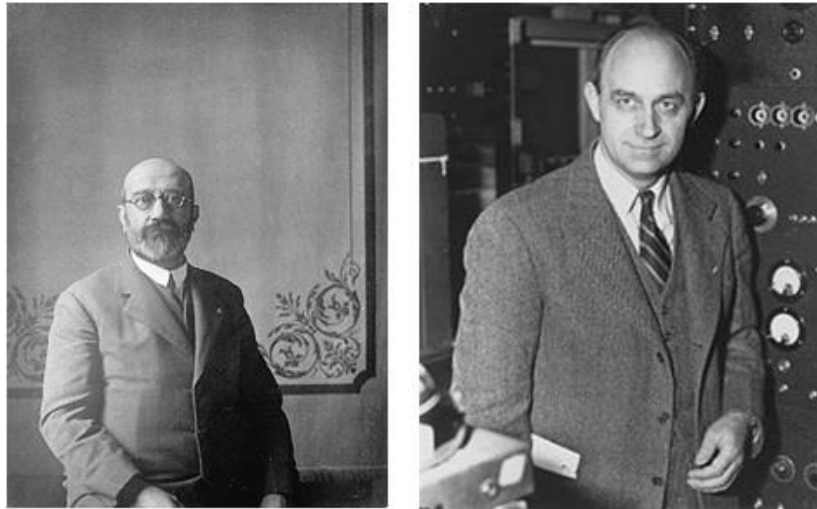


# First papers on Quantum Mechanics (1926)

- Inspired by Schrödinger's papers and by Born's paper on scattering, Fermi writes his first contributions to Quantum Mechanics in the form of wave mechanics
- “Zur Wellenmechanik des Stossvorganges”, *Zeitschrift für Physik* 40, 399-402 (1926).
- (with E. Persico) “Il principio delle adiabatiche e la nozione di forza viva nella nuova meccanica ondulatoria”, *Rendiconti Accademia dei Lincei* 4, 452-457 (1926).
- “Nuova Meccanica Quantistica”, *Atti della Società Italiana per il Progresso delle Scienze*, XV, 552-554 (1926).
- “Quantum Mechanics and the Magnetic Moment of Atoms”, *Nature* 118, 876 (1926)

# Importance of Pisan education

- It is worth underlining that the knowledge of the properties of diffraction gratings naturally refers to the Pisan experience of Fermi, whose supervisor, Puccianti, was one of the leading experts on the subject from the experimental point of view, but also from the theoretical one, as shown by the important suggestion he gave to Carrara for the realization of gratings capable of allowing a direct measurement of the wavelength of X-rays.



Il professore Luigi Puccianti ed Enrico Fermi

# Rome1926

- Fermi becomes full professor of Theoretical Physics in Rome (november 1926)



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