Contribution ID : **30** Type : **Oral**

Exchange interactions between Europe and Japan in the 1930s: Yukawa, Tomonaga and nuclear theory

martedì 19 dicembre 2023 13:00 (20)

Exchange interactions were introduced by W. Heisenberg in 1926 in the context of the quantum mechanics of systems of identical particles, and soon allowed to successfully address numerous problems in atomic, molecular, and condensed matter physics, such as multi-electron atomic spectra, chemical bonds, ferromagnetism, and electron-electron collisions. After the discovery of the neutron in 1932, this concept allowed the systematic application of quantum mechanics to nuclear physics, being the basis of theories of nuclear structure developed, among others, by Heisenberg and E. Majorana. Over the subsequent decades, this idea morphed into the modern understanding of fundamental forces as mediated by virtual particle exchange, in the context of quantum field theory. In this long story, a crucial role was played by two Japanese physicists, H. Yukawa and S. Tomonaga, who were among the first Japanese to be exposed to the principles of the new quantum mechanics, and were strongly influenced by the above mentioned work. Within a few years, Yukawa conceived his decisive idea of a nuclear interaction mediated by virtual mesons, acknowledging crucial input by Tomonaga, who in the same period was investigating the range of proton-neutron interactions. In this contribution, we reconstruct the role played by Japanese physicists in the 1930s, towards the modern understanding of fundamental forces. A clear picture emerges also of the influence of European scientists in shaping the development of quantum concepts in Japan.

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Session Classification : History of Physics

Track Classification : History of Physics & Teaching