SUBARTICLE

Biography of Goeppert Mayer

Clarissa Ai Ling Lee

One of the most groundbreaking contributions to modern nuclear physics came from Maria Goeppert Mayer, a theoretical physicist, for her work on the nuclear shell model of the atom that was later to earn her a Nobel Prize in physics. The nucleus of the atom, as one might have learnt in high school physics and chemistry, consists of protons and neutrons. In the nucleus are ratios between the neutron and proton that can vary. The nucleus is surrounded by an electron cloud in the form of an imaginary shell-like structure with specific rules on why there are a certain number of electrons, the how and why of their decay, and the how of classifying and predicting the energy levels of the electrons for the different elements that exist. Goeppert Mayer found that the stability or instability of the nuclear structure, or even why odd-numbered isotopes (atoms sharing the same mass that have different numbered neutrons) were less stable than even numbered ones, were then still rather unknown.

Accompanying Materials

Methodology & Intellectual Context
(https://adanewmedia.org/2013/11/issue3-lee/)

Biography of Noether
(https://adanewmedia.org/2013/11/issue3-lee-accomp1/)

Biography of Goeppert Mayer
(https://adanewmedia.org/2013/11/issue3-lee-accomp2/)

On Speculative Science Fiction
(https://adanewmedia.org/2013/11/issue3-lee-accomp3/)

Epilog
(https://adanewmedia.org/2013/11/issue3-lee-accomp4/)

At the time when Goeppert Mayer was working through the problem of the nuclear structure model and the 'magic number' in terms of how many electrons can maximally occupy one shell with stability, discoveries were already made with regard to the beta-emission of the electrons demonstrating the decay of the electrons and how that could be added up in relation to the nucleons. At the same time, there were major developments in quantum mechanics such as in the spin orbital and angular momenta of electrons. As Noether's work was about developing a big picture of the field in quantum theory, Goeppert Mayer's findings fit perfectly with the mathematical ontology Noether developed.

To think about the atom in the structure of a 'shell' ran counter to the concept of the "liquid drop" model of the atom that suggested the nuclei consisted of uniform density and that all the subatomic particles mentioned were configured, as a whole, in the form of a liquid drop, with differences in the forces observed in the interior and surface level of the nucleon. In this model, the fermions (protons, neutrons and electrons) were virtually ‘bunched’ together.[1] Goeppert Mayer’s other significant (but also related) contribution was the nucleonic pairing involving even and odd number nuclei through the manipulation of spin numbers and the angular momenta at ground state (the physics of ground zero), which would have implications for how the ‘coupling’ between particles could be perceived in latter day developments in particle physics, especially in the examination of inelastic collision and decays into ever more fundamental particles than the fermions.

Goeppert Mayer’s work has been important for thinking about energy and the construction of the most elementary entities. However, it was submerged within a discourse of physics dominated by a group of rather influential men, from Born to Fermi.[2] Within that context of epistemic development, Goeppert Mayer’s pioneering contribution was positioned against the need to reconcile the data observable within experiments of an already existing ontology. In other words, her contribution has changed how one would think about an aspect of the atom and provided the impetus for further work in nuclear physics on some of the most fundamental questions in quantum theory regarding the property of spin, quantum ‘jumps’ (now known as the behavior of electrons within the constraints of the Exclusion Principle disallowing two fermions of similar spin to be on the same quantum state while dictating the movement of the fermions between the orbital shells of predetermined quantum energy), and the differential properties of the nuclei. However, her work did not actually change the way quantum mechanics continued to be interpreted at that time. She later produced a thoroughgoing book on the subject, *The Elementary Theory of Nuclear Shell Structure*, in collaboration with J. Hans D. Jensen, which was published by Wiley in 1955.

Nevertheless, it is difficult to tease out the specificity of her contribution from all the contributions made by the other male and (a small number of) female physicists whose approaches to their individual research problems added cumulatively, but never in a distinctively linear manner, to the knowledge at hand. One might say that she had proposed an ingenious explanation of the idea before the other person did or in conjunction with the other people, as demonstrated by the shared Nobel Prize.

A rigorous analysis of the social context embedded in the production of the physics theories requires, foremost, differentiation between the internal-analytical aspect of the theories derived from mathematical proofs and computation, and the epistemic drive that produces the predictions and enables the experiments. One also has to attend to the external-experiential aspects that involve certain ideologies, sets of scientific beliefs, as well as institutional hierarchies and constraints that drive the research programs that are the impetus for the dominance of certain models over others. Once the differentials are teased out, one would soon discover how sharp lines cannot be drawn around certain epistemic practices. At the same time, there are varying levels of oppressions involved in the insistence of specific ideologies that confine interpretations in a way that has nothing to do with obvious correlations between mathematical concepts and physical states, but the preference for advancing certain values and standards.

Goeppert Mayer went against the grain of accepted beliefs by working on a project that did not arouse interests from among the most influential physicists of the day, with the exception of Enrico Fermi (see Jardins 157-200). Most official accounts would concentrate on the veracity and scientific value of her contribution, and its later reception. However, one does not know the intricate details of the social negotiations she had to perform unless one could access her correspondences or personal journals; she had occupied positions of no power in the university hierarchy, from 'voluntary' to low pay in most of the universities to which her husband, Joe Mayer (the physical chemist) was appointed (see Mozkowski). Similar to Noether, she needed her work to be validated and vouched for by the influential men in her milieu. At the same time, she did not allow herself to be dissuaded from her convictions. While many of the physicists she worked with were enamored with big accelerators and a macro perspective of the universe from the top, Goeppert Mayer was interested in how the details could be the key to changing existing ways of thinking about our universe, which she quietly revolutionized with minimal fanfare.

From what we can see from this and the previous section, the normative body, a body formed of coalescence between the two women scientists and all the other scientists, in their combined interactions with abstract knowledge, should be disrupted during the valuation of that knowledge through political and social interventions performed in concordance with the analysis of that knowledge. We know that knowledge is not autonomous and that even the most mathematical of knowledge can be made receptive to social epistemological arguments. Such an understanding indirectly informs my attempt at objectively confronting epistemic formations that have always been presumed as discursively inviolable. Hence, the knowledge arising from these highly mathematical sciences can become the inspiration for a new specter of speculative feminist science fiction.

Footnotes (returns to text)

1. A brief and concise history of the liquid drop model, and the physics that developed around it, can be found online in a talk given at the Max Planck Institute for the History of Science by Roger Stuewer, "**An Act of Creation: the Meitner-Frisch Interpretation of Nuclear Fission**

(http://quantum-history.mpiwg-berlin.mpg.de/news/workshops/hq3/hq3_talks/17_stuewer.pdf) ." The title refers to Lise Meitner, who had contributed enormously to developments in nuclear physics through her extensive theoretical work on nuclear fission, as the title of the talk suggests, a work that, once again, failed to be recognized. There is also a discussion of the contribution of Meitner, and Marietta Blau, in chapter three of Peter Galison's *Image and Logic: A Material Culture of Microphysics*. Under-appreciated and under-acknowledged female physicists played important roles in the early development and transition between radiation and nuclear physics, making discoveries through using the most rudimentary instruments available to them. According to Galison's argument, they were quite involved in a physics that privileged the image of the data as opposed to the highly mediated, abstract logics that particle physics experiments are involved in today.

2. As Julie Jardins has shown, while Goeppert Mayer followed her instinct, she did not work alone but always in collaboration with another prominent male physicist, an example being Fermi. For a more conclusive confirmation, see the oral transcript of an interview conducted with her by Thomas S Kuhn for the History of Quantum Physics Project. I was fortunate that the Niels Bohr Library had generously supported my research at its library in the summer of 2010, during which I was able to go through the profiles of the various eminent and influential figures, mostly males, who contributed in myriad ways to the shaping of quantum physics into the form we recognize today. However, I could only rarely locate the female physicists from among the profiles found in the archive.

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Ada: A Journal of Gender, New Media, and Technology
ISSN 2325-0496