Eugene Wigner and the bliss of the ‘Gruppenpest’

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In a series of papers written between 1926 and 1927, Eugene Wigner was the first to deploy the apparatus of group theory across the territory of quantum physics. Thus, he was able to show that, for instance, the multiplet structure of atomic spectra is a consequence of the transformation properties of atoms with respect to space rotations and of electrons with respect to permutations. While the historical significance of Wigner’s early work is widely recognized, it is nonetheless often treated as a “mere application” of already existing mathematical tools to the analysis of problems that had been solved previously by other means.

Indeed, when Wigner published his papers, group theory was already a fully developed field of mathematics, the details of atomic spectra had long been interpreted in terms of angular momenta, and the importance of symmetries in studying the behaviour of physical systems was widely recognized, most notably thanks to Noether’s formulation of a theorem (1918) that links symmetries to conservation laws in classical mechanics. Moreover, some results presented in Wigner’s early papers were anticipated by Werner Heisenberg – Wigner “merely” provided their rigorous proofs.

How far and in what sense was Wigner’s contribution essential? If his was only a trivial step, why was it left to him to take it? He had never worked on quantum theory or atomic spectroscopy before, and his mastery of group theory was so limited that, by his own admission, he had to rely on the advice of John von Neumann in order to be able to move on with his computations. Still, he showed a remarkable faith in the usefulness of group-theoretical methods, while many physicists would not just neglect, but even oppose them as a “Gruppenpest.”

All this suggests that there may be more than meets the eye in Wigner’s “mere application” of groups. One way to gain a better understanding of the significance of what had actually happened is to look into the details of Wigner’s early work, its background, and its development, and to compare it to the approaches of other authors who dealt with similar problems. Particularly intriguing is a comparison with Hermann Weyl, who summoned group theory to aid in the development of quantum mechanics as early as 1925. However, Weyl's deep engagement in pure mathematics prevented him from applying his vast group-theoretical expertise to tackle the problems of the day before Wigner did.

This paper will present some preliminary results from a study on Eugene Wigner's early work and its historical context, with particular attention to different notions of symmetry – both formal definitions and operational implementations – in mathematics, classical and quantum physics and, especially, in crystallography, the first research field which, in 1926, became a spring board for most of Wigner's subsequent career. This investigation may offer insights into one of the most subtle – and often neglected – aspects of advancing scientific knowledge, namely its relation to mathematical form. Wigner is an ideal subject for such a study because, right from the outset, he possessed a talent for exploring and exploiting the interplay between phenomenological data and mathematical structures or, to put it in his own words, in taking advantage of "the unreasonable effectiveness of mathematics in the natural sciences." It was a talent running as a thread through all of Wigner's work, also emphasized in Wigner's Nobel Prize citation, which reads "for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles."

In his Nobel lecture, Wigner underscored the special role that symmetries play in quantum physics, a role to which he seems to have been particularly receptive, in contrast to other physicist of the day. What appears in hindsight as a "mere application" may, in fact, be the result of a widely internalized shift in scientific thinking and language that Wigner's work helped to foster.

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