

Einstein's Quantum Theory of the Monatomic Ideal Gas: Non-statistical Arguments for a New Statistics

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Abstract:

In 1924-1925 Einstein made an important step in the quantization of the ideal gas, i.e. of a system of non-interacting, massive particles confined in a volume. He presented his quantum theory of the monatomic ideal gas in three papers, published in the Prussian Academy Proceedings. The first two papers were written as a two-part article with consecutive equation and paragraph numbering and are, in fact, famous papers in the history of quantum physics, introducing what is now known as Bose-Einstein statistics. The third paper is very different. It presents additional evidence for the correctness of the new theory and attempts to extend and exhaust the characterization of the monatomic ideal gas, while cautiously avoiding statistical or combinatorial arguments. Despite the relevance of Einstein's introduction of a new statistics, very few historical works refer to the third paper. Neither did it receive a lot of attention at the time of its publication; we hardly have found references to it by contemporaries, and references to the paper are scarce even by Einstein himself.

We will analyze the contents and arguments of the third paper. From a historical point of view, the fact that Einstein wrote a non-combinatorial paper after expounding his new theory of the quantum ideal gas in two prior articles points to a deeper conceptual problem. There are indications that Einstein himself may not have realized the full implications of the new way of counting, despite his earlier work on black-body radiation. Thus, the ambiguities in the third paper of his quantum theory of the monatomic ideal gas illustrate Einstein's confusion with his initial success in extending Bose's results. We will try to account for the paper's gestation period, in particular as regards the role that Paul Ehrenfest would have taken in it and we will also contrast it with previous and later reflections by Einstein himself. Finally, we will formulate some conjectures as to why this paper met with cold reception regardless of its historical and systematic interest.