Random Fluctuations in Electroscopes and Microscopes

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Abstract:

Almost two decades before the advent of quantum mechanics, the idea that the basic laws of nature could be indeterministic represented the prevailing view among Viennese physicists. Vienna Indeterminism – as I call this tradition that was first touted in Franz Serafin Exner's 1908 inaugural address as rector of the University of Vienna – can be summarized by three tenets. i) The highly improbable events admitted by Boltzmann's statistical derivation of the second law of thermodynamics exist. (ii) In an empiricist perspective, the burden of proof rests with the determinist who must provide a sufficiently specific theory of microphenomena before claiming victory over a merely statistical theory. (iii) The only way to arrive at an empirical notion of objective probability is by way of the limit of relative frequencies.

In this paper I want to emphasize the empiricist element in (ii) by focusing at the years before Exner's speech. This involves two of the three research fields then characteristic of the Exner group, to wit, atmospheric electricity and radioactivity (radium research). In contrast to Boltzmann's statistical derivation of the second law of thermodynamics and the debates about atomism, research in these two fields was dominated by a description of the phenomena and explorative experimentation with a shared instrument, the electroscope. It is important to note, however, that the Viennese combined this descriptive approach with a solid understanding of Boltzmann's statistical mechanics. This quite specific Viennese mélange of methodologies, so I argue, permitted them to consider fluctuations ("Schwankungen") as viable candidates for physical laws – and not as disturbations of hitherto unknown underlying deterministic laws, errors to be explained or explained away.

This mélange was instrumental for two breakthroughs that occurred around 1905, Egon von Schweidler's theory of radioactive fluctuations and Marian von Smoluchowski's theory of Brownian motion. Both were propounded as descriptions of genuinely random phenomena, but their reception would become markedly different. Brownian motion was quickly viewed as decisive evidence for atomism, not least because the continuing validity of classical mechanics on the atomic level –at the price of the ergodic hypothesis – made it palatable to those insisting on a deterministic foundation of natural law.

Schweidler's fluctuations, on the other hand, were commonly conceived as a vehicle to better describe a given radioactive substance than as a phenomenon in its own right, let alone as a proof of indeterminism. The Viennese, contrast, emphasized their genuine nature. After Exner's rectorial address provided them with a general indeterminist outlook on the laws of nature, they even argued that Schweidler had definitely proven the indeterministic nature of radioactive decay. Schrödinger's 1919 paper on "Probability theoretic

investigations concerning Schweidler's fluctuations" represented definite and theoretically well-elaborated word from the Viennese on the matter. It played an important role in motivating the stance he took in his famous 1922 inaugural address "What is a law of nature?". In 1920, the Prague physicist Reinhold Fürth – who had worked on Brownian motion – even called fluctuation phenomena an interdisciplinary phenomenon ranging from the statistics of colloids (Brownian motion in the narrow sense) to fluctuations of radiation density, of molecular oscillations and of radioactivity (Schweidler's fluctuations).

This shows that the tradition of Vienna Indeterminism was not merely a philosophical movement, but counted on a complex research tradition that was driven by an empiricism prevailing even before Exner's adoption of the relative frequency interpretation would ease the conceptual understanding of fluctuations.