**Jean Perrin and the Philosophers' Stories: A Case Study on the Role of Case Studies in &HPS**

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The French physicist Jean Baptiste Perrin (1870–1942) is generally credited with providing the conclusive argument for atomism in the beginning of the 20th century (Brush 1968, Nye 1972, Chalmers 2009). Perrin's argument was based on the existence of thirteen different experimental procedures for determining Avogadro's number (N), including his own determinations based on the height distribution, mean displacement, and mean rotation of Brownian particles (Perrin 1909, 1916).

Being so successful in ending the 19th century atomic debates Perrin's argument has been the focus of much philosophical interest. We can discern two relatively independent strands of philosophical treatment in the literature. On the one hand, Perrin's case is often cited in philosophical discussions on experimental multi-determination. In this context, Perrin's offering of thirteen different methods for determining N is referred to as a classic example of experimental multi-determination (or experimental robustness). Other than this, however, not much analysis is devoted to the role that the multiple determinations of N actually played in Perrin's argument or in convincing the scientific community.

On the other hand, Perrin has been the object of detailed case studies aiming to capture the reasoning behind his successful argument for atomism. Strangely enough, the philosophers who have paid attention to Perrin's argument tend to downplay the role that the multiple determinations of N play in it. The reasoning behind Perrin's experimental strategy was initially interpreted as a case of a no miracles argument or as an inference to the best explanation (Harman 1965). Clark Glymour used it as an exemplification of his account of bootstrapping confirmation (1980). In a detailed analysis of the structure of Perrin's argument, Wesley Salmon presented it as a case of a common cause argument. Salmon's interpretation was one of the few that put a lot of emphasis on the role played by the concordance of independently established facts (Salmon 1978, 1984). Nancy Cartwright drew on Salmon's interpretation of the case, but because of her distrust of the theoretical laws in physics, presented it as an inference to the most probable cause (Cartwright 1983). Cartwright's account diminished importantly the role that multiple determination plays in actual experimental practice. The role of the multiple determinations of N was downplayed even further both in Deborah Mayo's interpretation of Perrin's experimental work as a severe test for the kinetic theory of gases and in Peter Achinstein reconstruction of Perrin's argument as supporting his account of evidence (Mayo 1986, 1995, Achinstein 2001). These different assessments of what stood behind the success of Perrin's argumentative strategy are to be expected insofar as the various interpretations, rather than 'disinterested' reconstructions of the rationale underlying Perrin's reasoning, seem more like efforts to present Perrin's case as a confirmatory instance for general theories of confirmation. Nevertheless, the situation seems to exemplify some of the most difficult problems scholars cite when discussing a fruitful collaboration of history of science with philosophy of science (see for instance, Brooke 1981 for some of the problems faced by the case-study approach).

I claim that this situation should not considered as an obstacle for a fruitful combination of historical and philosophical perspectives as long as we distinguish between idealized and empirical or historically driven case studies. Whereas idealized case studies tend to use the historical material in order to elucidate and evaluate general reasoning patterns, historically driven case studies examine the significance of methodological arguments as scientists make them in concrete historical situations; they focus on aspects of scientific practice that may or may not be generalizable to other historical episodes

(Schickore and Coko 2013). Moreover, I argue that a combination of historical and philosophical perspectives is needed in order to understand the role that the multiple determination played in Perrin's argument for atomism and in convincing his contemporaries.

I argue that in order to understand the persuasive force of Perrin's argument we need to pay attention not only to the (a) historical 'slice' comprising the scientific work and the wider intellectual context of the early 20th century, but also to the larger temporal dimension. For instance, contrary to what most scholars seem to admit, there was an extensive and sophisticated experimental work done on the phenomenon of Brownian movement during the course of the 19th century. Although these experimental investigations contributed more in excluding possible causes of the phenomenon rather than establishing a positive causal explanation, by the end of the 19th century, they had left the molecular-kinetic hypothesis as the most plausible explanation of Brownian movement. A sensitivity to the temporal dimension of scientific work is also needed in order to distinguish between two different kinds of independence involved in the various determinations of N: some of the procedures for determining N were not only theoretically, but also historically (or 'genetically') independent.

A closer look at the details of Perrin's experimental work reveals that the strategy of using multiple means of determination is involved at many levels; not only in the determinations of N, but also in the determinations of the various parameters and theoretical assumptions required for the calculation of N. Another relevant distinction in Perrin's case is that between quantitative and qualitative multi-determination. Arguments aiming to connect Brownian movement with the molecular hypothesis based on the qualitative characteristics of the phenomenon were common in 19th century experimental investigations, but it was the quantitative agreement between the numerical values obtained for N by independent procedures that played a crucial role in convincing the scientific community.

Finally, Perrin's case serves to highlight a difference between two concepts often not distinguished in the philosophical literature; namely, between 'robust' and 'multiple-determined'. Whereas the first is more fitting for experimental results or phenomena that remain invariant despite changes in the experimental setting, the second is more appropriate for results obtained by independent experimental procedures. Arguments from robustness rely on a notion of invariance, whereas arguments from multiple determination rely on a notion of concordance. The two kinds of argument played different roles in connecting the movement of Brownian particles with molecular motion.

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