Review of R. Stalley, *Einstein's Generation*, for *Metascience* review symposium

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This is a very good book, re-evaluating relativity physics in the context of its times. Richard Staley sets out to accomplish worthy and familiar historiographical aims: to reassess previous generations' scientific heroes; to embed intellectual achievement in its cultural framework; and, to vaunt the role of instrumentation and empiricism in knowledge creation. The timescale of the book is a single generation, the thirty years between the Michelson-Morley ether drift experiment (1881) and the first Solvay Council and textbook focused on special relativity (1911). His attempt to 'explore the way arcane results might carry the cultural freight of worldviews' (p.3) largely succeeds.

But Einstein himself, and even relativity – both key words in the title – are not the primary focus of this book. For example, the work and career of Albert Michelson vies for critical examination as a potential co-configurer of communities. There is a certain justice and incongruity in this approach. The American Michelson was a diffident supporter of relativity at the best of times, and so could serve as an historical counterfoil: he represents simultaneously one pole of the experiment-theory axis, membership in a nascent national community that was subordinate to Germany's scientific primacy, and resistance to the emerging ideas of modern physics. His significance to the book is belied by its promotion, however. Michelson's name does not appear in the rear cover synopsis, nor indeed among the two dozen physicists depicted and named on the front cover (several of whom, in fact, go unmentioned in the text). Nevertheless, in narrative terms Michelson's 'guest star' role in the story, even if un-advertised, is interesting and well presented.

The author deservedly highlights Michelson in two of the ten chapters of this book (nearly one-third of the text) and in his previous publications, but could make the case more persuasively. Michelson's experimental rigour extended precision measurements in optics by orders of magnitude, and he applied his devices to new investigations in ways that inspired awe, if not emulation, by his contemporaries. Chapter 2 provides a narrative

account of Michelson's velocity of light and ether drift research, detailing the naval and astronomical context in which the novel experimental apparatus evolved. In the following chapters Staley argues that, despite this disciplinary linkage to astronomy, Michelson was able to co-opt research in optics and mechanics to pursue work in metrological standards. Given this important connection of physical standards to new physics – and the author's legitimate claims about the neglected role of empiricism – it would have been valuable to have devoted more attention to the German work in this field so closely linked to the transition to modern physics. At the fin de siècle, the Physikalisch-Technische Reichsanstalt melded optical research with industrial collaborations, yielding careful studies of blackbody radiation that culminated in the theoretical developments of Max Planck (Cahan 2004). The book devotes chapter 6, however, to an equally impressive experimental tour de force, the studies of the electron by Walter Kaufmann.

The focus throughout these chapters is on experimental ingenuity and instrumental refinement, and on the difficulties of connecting the interferometer with issues important to contemporary physicists. As Staley underlines, Michelson was dismayed at both the null outcome of the ether-drift experiment and by the lack of interest shown by his contemporaries through the 1880s. During the following decade, critics analyzed the ether-drift experiment to suggest subtle experimental limitations rather than unambiguous properties of the ether. The wealth of narrative description provided in these chapters hints that the considerable tacit knowledge required for successful interferometry may have convinced Michelson's peers that such experiments were untrustworthy and beyond wider application. Extreme instrumental elegance and experimental finesse could be interpreted as self-limiting, isolating the investigator rather than inaugurating a new research tradition. Michelson's 'facts' were contested, and his social influence, it seems, were slight.

As a famously ascetic investigator working in an environment bereft of a physics tradition, and who suffered graduate students ungladly, Michelson seems an unlikely candidate for discussion of the growth of new communities. The author observes that the young Michelson was indoctrinated into an active culture of experimentation in velocity of light measurements owing to patronage and genial competition in the USA, and to sojourns in Berlin, Potsdam and Paris. Even then, however, Michelson's experiments were not replicated or extended by others. In comparison to the book's ample depiction of experimental innovation and focus on instrumentation as a career theme, evidence of

Michelson's sociological influence is comparatively sparse. It might be argued that, because his exploitation of the interferometer as a readily-mutated instrument was to occupy much of his career, he can be characterized more accurately as a *research-technologist* (Joerges and Shinn 2001) than a physicist akin to his contemporaries in France and Germany. In fact, Staley notes the tensions in Michelson's relations with the physics community owing to his focus on 'instrumental unity' (p. 69). Yet his claims concerning discipline formation are not well demonstrated because the social and intellectual attributes of Michelson's peers – the generation preceding and contemporaneous with Einstein – are sketched only selectively in subsequent chapters. In short, while presenting much historical material of great interest in its own right, the relevance of these chapters to the overall argument could be made more strongly.

Beyond the work of such iconic figures, though, the book seeks to highlight their community connections through public events. Two meetings of physicists provide contrasts that are comparable to those between Michelson and Einstein. The Paris Congress of 1900, organised by the French Physical Society, has faded from collective memory today despite commissioning papers from some of the most eminent contemporary physicists and attended by some nine hundred (more than half of all) practicing physicists. Occurring just over a decade later, however, the first Solvay conference is still celebrated as a seminal moment in the synthesis of a new physics and its adherents.

The book offers a more analytical core, however. Staley's stated theme concerns transformations. He offers a revisionist account of the classical-modern transition in physics, and suggests other generic transformations, including those engendered by instruments, experiments, theories and disciplines. Malleability of interpretation – involving 'subtle transformations in the meaning of the work' (p. viii) – is at the heart of this. Building on critical studies of a previous generation of historians of relativity, the book focuses on the work of some neglected key actors, and how a common understanding of Einstein's work developed among his contemporaries.

The book's attention to disciplinary formation, in particular, is a timely addition to current scholarship. Beyond the goal of corrective assessment of historical episodes, the book seeks to explore the opposing forces of disciplinary change and cohesion. This does not involve the formation of a new discipline, of course, as physics then had a long genealogy

and established coterie of subject-specific and geographically-centred communities. Instead, it traces the shifting ideas of participants in this turn-of-the-century revolution. The author valorises the work and material culture of experimentalists such as Michelson and Kaufmann to obtain a more nuanced account of how support for relativity physics grew. Arguably, relativity physics was a looser coalition of interests than a genuine sub-discipline, although others certainly sprang up at this time: physical optics, recognized by a spate of early Nobel Prizes and instantiated in Albert Michelson's generic form of the interferometer – the heart of the Michelson-Morley experiment –is the prime example of a new intellectual union between experimental finesse and theoretical elegance.

In the Introduction, Staley motivates his study of what he dubs *disciplinary memory.* His term refers to practitioners' interpretive work to give meaning to innovative science by inter-relating old and new research techniques and findings. These physicists' histories, written shortly after or even during important episodes, are investigated to assess how 'canonical narratives of disciplinary development' help to 'inform physicists' sense of the nature, past and future of their discipline, and thereby contributes to their identity as a community' (p.14). Not surprisingly to historians, the author shows that this memory is selective, and that it neglects important aspects of physicists' work.

Part II, on the World's Fair and Congress of Physics in Paris in 1900, is a delightful evocation of the confluence of machine-centred modernism, national competition and scientific expertise. The events illustrate shifting attitudes and goals. The intellectual and cultural atmosphere sometimes summarised as 'fin de siècle physics' is sketched well. In the decades straddling 1900, the new phenomena of rays (or particles?) were challenging the somewhat jaded attitude of late nineteenth century physicists tying up loose ends in mechanics, thermodynamics and optics, and extending measurements to the ever-greater exactitude. Indeed, Michelson himself famously suggested that many of the great scientific advances of the nineteenth century had resulted from increasing experimental precision, and that 'our future discoveries must be looked for in the sixth place of decimals'(Michelson 1902, 24). As Staley illustrates, a cascade of experimental studies unsettled the snug arrangements of physics and its developing industrial alliances. The Congress chapter explores the existing goals, methods and concepts of physics through the conference presentations of key physicists such as Poincaré and Kelvin. The book identifies the discovery of the electron as a seminal shift highlighted at the conference, and important to the subsequent development of relativity (the empirical evidence for the

electron and its interpretation by theoreticians occupies the third section, and one-quarter, of the book).

This historiographical approach of deconstructing the accounts of historical actors is fruitful, but could be extended well beyond the study of a World's Fair, two international congresses and early syntheses of the relativity principle, as developed in Chapters 4, 5, 8 and 10. While emblematic, these public demonstrations of community and consensus provide a limited perspective. The Paris Congress attracted a significant fraction of the world's physicists, but their perceptions – as attendees rather than presenters – are difficult to discern. As a meeting reporter for the *Physikalische Zeitschrift* reported to his chagrin, there was no printed list of participants, and no designated pub to encourage collegiality! The author notes that 'the appearance of an individual's work in these arenas rendered it representative' (p.135), but it might be argued that such representations were actively constructed to suit national and institutional objectives. As a sample of community, international exhibition and conference presentations may be skewed towards the more senior, higher status and economically or politically powerful. While there is considerable merit in tracking this self-defining elite, it can constrain our notions of the intellectual community, leading to the practitioners' accounts addressed by disciplinary memory. I would argue, instead, for a more democratic approach. The formation, consolidation and dissemination of disciplinary identities can, for example, be studied further by tracking cohorts and research networks (e.g. core-set analysis (James 1983)), shared practices and hardware (Galison 1997), and by tracing other expressions of nascent community perceptions and the related dimensions of professionalization and occupational niches (Johnston 2006). A more ethnologically and sociologically sophisticated analysis could be fruitful for understanding this period and its participants. On the other hand, given the ambiguity inherent in the book's title, 'Einstein's generation' can, taken as a pun, fairly describe the concepts and support that he generated rather than the cohort in which he worked. In this respect, the book fulfils its aim.

Chapter 8, on the histories of relativity, uses a variety of mainly published sources to examine how Einstein's work was interpreted, evaluated and assimilated by his contemporaries. The perceptive juxtaposition and analysis of accounts by key commentators – including Einstein, Lorentz, Planck, Minkowski, Sommerfeld and a host of subsequent historians – indicate how an early plurality of opinion coalesced by 1911 to wide support for relativity theory. Even more satisfyingly, the subsequent chapter

develops the useful point that 'classical' physics was an idealization first defined *en masse* after 1900 to serve as the background to 'modern' physics. This fascinating 'story of a word' reveals that the label hid a lack of consensus about how the concepts of physics should be categorised and remodelled via relativity theory.

Overall, this book is a valuable addition to the literature. It redresses an imbalance in the historiography of relativity, transforming it from predominantly a theoretical achievement to a synthesis of experiment, theory, materiality and scientific perceptions. In building towards this analytical conclusion its chapters offer an invigorating, if sometimes uneven, combination. Topics are heterogeneous and individualistic, and range from electron apparatus to the Nobel Prizes; from a Gustav Klimt painting to the notion of rigid bodies; from manufacturers' exhibition displays to ontology (should the ether or the electron serve as 'the core of a new worldview'? (p.219)). This amalgam necessarily yields jarring perspectives and varying levels of detail more easily assimilable on the Chapter and Section level than as a monograph. Gaining a fuller sociological sense of 'Einstein's generation' as a community of working scientists who melded theoretical concepts, zeitgeist and experimental innovations may demand even more discordant methods and a correspondingly difficult synthesis. While this implies a move further away from the neat practitioners' accounts, it offers a potentially more accurate, and ultimately satisfying, analysis.

This is no criticism of Richard Staley's achievement; he has provided a nuanced and multi-faceted account of the rapid fin de siècle transition in physics, rehabilitating half-forgotten investigators and revealing the importance – and often neglect – of scientific craftsmanship and empirical evidence. In the process, his readable and eclectic book demonstrates the value of current historiographical approaches.

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