MATTHEW STANLEY'S *PRACTICAL MYSTIC: RELIGION, SCIENCE, AND A. S. EDDINGTON:* Valence Values and the Late-Victorian Science-Religion Interface/Divide—A Review Essay

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The relationship of science to religion and literature continues to be an issue of vexation, especially here in the U.S. A logical way, perhaps, to begin this review essay on a late-Victorian, early-modern work integrating science and religion is by observing that in this period the walls between science and other epistemics were quite porous. In fact, the existing familiar scientific divide began to experience increasing separation and specialization in the nineteenth century. The rise of science is arguably the defining characteristic of the nineteenth century, which saw the formation of the British Association for the Advancement of Science (1831), the Royal Astronomical Society (1831), the Entomological Society (1833), the Botanical Society (1836), the London Electrical Society (1836), the Royal Agricultural Society (1838), the Microscopical Society (1839), the Pharmaceutical Society (1841), the Chemical Society (1841), the Ethnological Society (1843), the Paleontological Society (1847), and the Institution of Mechanical Engineers (1847). The mid-1850s witnessed the rise of evolutionary biology and work on the dynamical theory of heat, followed in the

1860s by the launching of the journal *Nature*. Also unique to the nineteenth century was the restructuring of the natural sciences. Physics, now more inorganic than organic, became separated from chemistry, chemistry from its age-old alchemist superstitions, and geology from its religious ties to the Mosaic cosmogony. Only astronomy and botany remained relatively untouched.

Almost without exception, nineteenth-century scientists and writers made regular excursions (and not border raids) in each other fields, drawing liberally from them for illustrations and examples as they felt led. Immersed within culture, and wrestling with "metaphor and analogy," science and literature sponsor the "ecumenicism of creative thought," with science not "divorced from realities of human creativity and social context" (Gould 6–7). Physicists as well as social prophets of the nineteenth century, resisting ownership and boundaries, indeed property, readily annexed each other's language and authority. The "fascination with the 'other,'" Gillian Beer finds, coincides not surprisingly with "the rise of interdisciplinary studies" (*Open Fields* 117). Nineteenth-century scientists felt authorized to offer critiques of literature, showing that the period had yet to experience the kind of bifurcated, discipline-specific boundaries. And these were by no means fringe thinkers. Clerk Maxwell, for example, offered a critique of Charlotte Brontë's novel *Villette*, and in the very next breath turned to Michael Faraday. He also advanced an extensive critique of George Eliot's *Middlemarch*, comparing the plot of the novel to an intricately worked out solar mythology. In an essay on "English Hexameters" for the *North British Review* for May 1853, William Whewell found the versification of Arthur Hugh Clough's dramatic poem *Bothie of Toper-na-Fuosich* "uncouth and licentious" to the point of repelling "the most indulgent reader." He thought the accent, phraseology, and imagery extravagant as though they were "part of the jest." Still the work, he felt, possesses "considerable charm" (Thorpe 66). These scientists drew widely from literature and Scripture for methodological, metaphorical, and metatextual purposes.

Michael Faraday turned repeatedly to Shakespeare, especially in his classical work *The Chemical History of a Candle* (1862), and Arthur Eddington, the scientist who occupies our attention in this review essay, was attracted to the Alice stories of the Oxford mathematician turned novelist, Lewis Carroll. He also drew heavily from Ovid's *Metamorphosis* and Edward FitzGerald's *The Rubaiyat of Omar Khayyam.*

Furthermore, many of these leading men of science in the nineteenth century seem unwilling or unable to renounce the role if not the centrality of religion and faith from their life, work, and experience. For Clerk Maxwell, especially, "the complementary tasks of the natural philosophy professor and the minister of Christ were to facilitate that recognition." He and his cadre of North British scientists of energy "had not only embedded their new natural philosophy in the cultures of Presbyterianism but had also been ready to deploy that natural philosophy in the service of a Christianity suitable to the wants of Victorian Britain" (Smith 240, 307). Science and religion were inextricably connected in the nineteenth century, the two, as Herbert Spencer argues in *First Principles* (1862), dialectically or correlatively fundamental to any approach to symbolic reality and nescience. Spencer's search was for a "fundamental harmony" between science and religion, "two great realities" that "cannot be comprehended," responding as they are to "different aspects of the same Universe" (16, 17, 53). The inseparableness of the science of energy from religion is quite recognizable among such Scotsmen as Clerk Maxwell and P. G. Tait, members of the North British group of physicists and engineers largely responsible for the construction of "the science of energy." This group of scientists, many of whom could not separate their science from their Calvinism or Presbyterianism, was crucial to the "discovery" of energy physics, important as it was to "the capitalist contexts of Victorian Scotland" (Smith 1, 3). As Crosbie Smith observes in his discussion of the new Scottish energetics, William Thomson, Clerk Maxwell, and P. G. Tait, "the science of energy" was "promoted as a natural philosophy in harmony with, though not subservient to, Christian belief" (172). The goal, as Smith observes, was to make energy a national science, accommodating it to the religious temper of the nation and at a time when "the boundaries between science and its publics tend to be highly permeable" (3). To describe their energy physics (thermodynamics), for example, Thomson and Tait employed the language of the Psalms and the Epistle of Peter:

> We have the sober scientific certainty that heavens and earth shall "wax old as doth a garment" [Psalm 102:26]"; and that this slow progress must gradually, by natural agencies which we see going on under fixed laws, bring about circumstances in which "the elements shall melt with fervent heat" [2 Peter 3:10]. With such views forced upon us by the contemplation of dynamical energy and its laws of transformation in dead matter, dark indeed would be the prospects of the human race if unillumined by that light which reveals "new heavens and a new earth" (2 Peter 3:13). (Qtd. in Smith 185)

Most Victorian thinkers, including Darwin, did not acknowledge or observe a real conflict between religions and science, believing as they did that the two practices deal with different, and not vastly different, trajectories of thought. Even a Christian apologist like John Henry Cardinal Newman, who assumed an accommodationist position in the wake of the challenge of Darwinian evolution, called for the two fields to be pursued along entirely different trajectories (see Newman's "Christianity and Physical Science," and "Christianity and Scientific Investigation"). That while in practice the two fields are different, epistemologically they are not, for when pushed to their ultimate limit, when confronted with the really hard questions, both practices fall back on myths or what Thomas Kuhn has nicely called "conceptual schemes." Victorians for the most part did not see the fields of science and religion as all that contentious, except for Lyell's geology and Darwin's evolution, which raised serious questions about the Mosaic cosmogony and the accepted creation account. The provocation came when Matthew Arnold, in *Culture and Anarchy* (1867–69), unwilling to carve out sacred space for science within the university curriculum, insisted that the humanities were central to moral culture, and that literary, not scientific, studies are best suited to nurture a critical sense of values. But Arnold's position needs to be historicized. As holder of the Poetry Chair at Oxford (and he was pontificating from that pulpit), Arnold was observing the curriculum changes taking effect. In a 29 December 1870 essay in *Nature,* entitled "Natural Science at Oxford," J. P. Earwaker, surveying the last decade, offers what he calls a "useful *résumé* of the opportunities held out to Natural Science students at Oxford." He observes that "The progress which Natural Science has made at Oxford within the last few years has far exceeded the anticipations of even the most sanguine of its promoters. . . . Year by year, the interest shown in these studies has steadily augmented, the number of undergraduates attending the University College Science Lectures has augmented in proportion as the number of these lectures has increased, and the School of Natural Science has become recognised as on a par with the other three great schools of Philosophy, Mathematics, and Law and Modern History" (170; see also "Oxford and Science," *Nature,* 31 December 1903, 207–14).

In challenging Arnold's view, then, of the humanities in "possession of the monopoly of culture," as Thomas Henry Huxley calls it (24), Huxley's *Science and Culture* calls the entrance of the physical sciences a "third army" or a "guerrilla force" into the fray. Arguing against Arnold's humanists, "Levites in charge of the ark of culture," Huxley wanted science to become a vital part of the university curriculum in its quest for truth. But the real watershed moment was C. P. Snow's brash assertions in his 1959 Rede Lecture about the so-called "two cultures" that drew the first wedge between religion/humanities and science. Snow's monumental *The Two Cultures and the Scientific Revolution* (1959) widened the fissure, the intellectual impasse, between the "two polar groups," science and literature. What resulted, says Michel Serres, is a "bifurcated relationship between science and literature . . . so distant that two eternities [seem] to be looking at each other like two porcelain dogs—like two stone lions flanking a doorway" (*Conversations* 47). And this reification has become even more polarized, occasioning, in part, the recent division of the arts from the sciences in the more traditionally conceived college of arts and sciences. (We know that there are other agendas driving this compartmentalization, not least of which are issues of legitimacy).

This, then, was the late-Victorian milieu that formatively lent shape to the early-modern world in which Arthur S. Eddington (1882–1944) lived, wrote, and performed science and religion. Eddington was a brilliant astrophysicist and devout Quaker who worked in England in the first half of the twentieth century. He is best known for his leadership of the expedition that measured the bending of starlight by the Sun's gravity and thus verified Einstein's general theory of relativity. However, even more importantly, Eddington pioneered stellar models, i.e., the use of physical law to understand the processes going on in the interior of stars. Matthew Stanley's quasi-biography, *Practical Mystic: Religion, Science, and A. S. Eddington* (Chicago, 2007), considers Eddington essentially the father of modern astrophysics. Professor Stanley has wisely chosen this particular period of time: we would learn very little about science and religion from studying a scientist from earlier times when devout belief was the norm among scientists. And we would learn perhaps even less from the study of a contemporary scientist, since these days a devoutly religious scientist is something of an aberration.

The book examines six episodes in Eddington's life: "The Quaker Renaissance," which, convinced that "Only an experiential willingness to embrace new knowledge could lead to a measure of truth" (26), brought Quakers "out of their so-called quietistic period of isolation [in the 1890s], revitializing the community for an active role in the modern world"; "Mysticism," the rejection of Dogma and "any claim for absolute truth," and the belief that "physical science should function the same way"; "Internationalism," the view that "there were certain problems in science that could be investigated only with international cooperation" (31), such as Eddington's support for Einstein's general theory of relativity, which presented him with the opportunity to reconcile German and British science; "Pacificism," the refusal "to separate his Quaker identity from his scientific one"; "Experience," that "instead of eliminating considerations of human values, positivism asserted their importance and relevance"; and that "a Quaker approach to religion would relieve all the tensions that had grown between science and religion under the dominance of materialism"; and "Religion in Modern Life," which, arguing against "the deterministic materialism of the Marxists" who "claimed that scientific thought required a dismissal of religion in favour of materialism," claims that "the idealistic defense of human will and experience" was "at the foundation of modern physics." Stanley argues that these values "generated particular interactions between his scientific career and his religious outlook" (10–14). Add to this Eddington's last episode and Stanley's seventh chapter, "Thinking about Values and Science," which concerns the last decade of Eddington's life when he developed what would become his "Fundamental Theory, and attempt to unify relativity and quantum mechanics through epistemology" (238).

Stanley has two main points: rather than discuss science and religion in the abstract, it is more productive to pick a particular religious scientist and to examine how religion and science interacted in that person's life and thought; and that this interaction is best understood in terms of what Stanley calls "valence values." It seems that Stanley has coined this phrase in deliberate allusion to chemistry, in which the valence electrons, those outermost electrons of an atom that in being shared between two atoms, bind those atoms together to form molecules. Thus Stanley claims that religious scientists have certain overarching values that affect both how they believe and how they do science; and that these values bind together the religious scientist's identity as a believer and as a scientist into a seamless whole. The most powerful argument in the book is the one on seeking. Stanley points out that in the late nineteenth and early twentieth centuries the leaders of the Quakers performed a grand rethinking (the Quaker Renaissance) of their religion in an attempt to reconcile their beliefs with modern science and indeed with modernity in general. One outcome of this rethinking was a commitment to "seeking," which is the notion that the Quaker religion has no fixed doctrine, but that each believer would spend her/his life trying to get closer to the truth without ever claiming that s/he had attained it. Put this way, seeking is actually a good description of how all of science is done; but as Stanley points out, it is a particularly good description of how astrophysics is done. The objects of astronomy (planets, stars, galaxies, etc.) cannot be put on our laboratory benches and be subjected to our choice of tests and controlled experiments. Instead, we must use whatever observations we can make of these objects, combined with whatever laws of physics we have found, in order to understand how the objects of astronomy behave. Thus, always seeking truth without claiming to have attained it in final form is an even better motto for astrophysicists than it is for scientists in general.

However, Stanley notes that it need not have turned out that way. At the same time that Eddington did his work, his colleague and nemesis James Jeans advocated an entirely different way of doing astrophysics. In Jeans' view, one should apply to objects of astronomical inquiry only those physical laws that have been well tested in the laboratory and are well understood. To attempt to go beyond this, as Eddington did, was regarded by Jeans as nothing more than mere speculation unworthy of the name science. The problem with Jeans' view is that some phenomena are seen first in astronomical observations and only later in terrestrial experiments. Prominent examples include helium and nuclear fusion (to which one could add dark matter, which has been inferred from its gravitational effects on stars and galaxies, but which has not yet been directly detected). To adopt Jeans' method would be to put an unacceptable damper on progress in astronomy. In particular, Eddington showed that observations of light from the Sun and stars indicated a power source far in excess of that of any process then known except for radioactivity, and he presciently theorized that this power was due to the fusion of nuclei of hydrogen to form helium. And this was decades before the invention of the hydrogen bomb, and even before the detailed understanding of the theory of nuclear fusion or the experimental discovery of the neutron. This use of what observations one can get, what laws of physics are known, and inspired guesswork to fill in the gaps between the two is the hallmark of modern astrophysics. It is perhaps somewhat ironic that present day astrophysicists, regardless of their beliefs or upbringing, are acting in accordance with the tenets of the Quaker Renaissance, in no small part due to the influence of Eddington on the ethos of their field.

While astrophysicists take for granted the methods of their field, all scientists tend to take for granted that science is an international endeavor. This is even more true for astronomy than for other sciences, because some astronomical events (e.g. eclipses) are only visible from certain parts of the Earth, and so information on these events must be gathered from a particular location, and then shared worldwide. However, Stanley points out that internationalism in science need not have turned out that way. In particular, during World War I nationalist passions ran high, and scientists, being only human, were certainly not immune to this. The war produced a severing of ties between British scientists and their German counterparts, and it was not clear at the time whether the damage would be repaired. In this context, Stanley points out that internationalism is a value of Quakerism as well as of science. Thus Eddington as a scientist and Quaker was highly motivated to re-establish the links between British and German science. The eclipse expedition of 1919 was a set of observations done by British scientists to test (and as it turned out to verify) Einstein's theories. Einstein had predicted that the light from stars would be bent by the gravity of the Sun, and, furthermore, that the amount of the bending would be exactly twice the value that one would obtain from Newton's theory of gravity and Newton's corpuscular theory of light. The amount of bending is very small and can only be observed for stars whose position in the sky is fairly close to that of the Sun. However, such stars are visible only during a solar eclipse since otherwise their light is drowned out by the much larger amount of light that we receive from the Sun. Eddington not only led the expedition, but also did much afterwards to publicize both the results of the measurements and Einstein's theory of relativity. The result was that Einstein became an instant celebrity and that internationalism in science was restored (at least until the Second World War; but that's another story and not one that is covered in this book).

An entire chapter of Stanley's book is devoted to Eddington's efforts to explain science, especially the new sciences of relativity and quantum mechanics, to the general public. This chapter is a fascinating portrait of the public perception of science (at least in Great Britain in the period between the wars). However, the chapter does very little to advance Stanley's nuanced ideas on the relation between science and religion. The main influence of religion on Eddington's popularizations seems to be his notion that the quantum mechanical uncertainty principle establishes freedom of the will. However, this argument is a very weak one, as was pointed out at the time by Bertrand Russell. The uncertainty principle introduces an element of randomness into nature; but randomness is the very opposite of the purposeful activity that we associate with a free agent and thus cannot be its underpinning. In this case, Eddington's religion seems to have had a wholly negative influence on his science, or at least on his philosophy of science. Another chapter is devoted to Eddington's stance as a pacifist in wartime. This chapter is a stark portrayal of the dilemma of British pacifists during World War I who came under enormous pressure from both the government and their fellow citizens to give up their beliefs and succumb to the draft. However, the chapter has very little to say on the subject of science and religion, the only connection being that Eddington was simultaneously pursuing two different draft exemptions: one based on his work as a scientist, and the other based on his beliefs as a Quaker.

One episode that is treated in the book briefly but with great insight is the Eddington-Chandrasekhar controversy. Chandrasekhar (not the famous cricketer) was an Indian astrophysicist who did his graduate and postdoctoral work in England and then spent the rest of his career in the United States. He had developed a theory of white dwarf stars. These are stars with the mass of the Sun and the size of the Earth. They are thus enormously dense (a teaspoon of white dwarf matter has about as much mass as three elephants). A star's own gravity tends to pull it inward, and the star is kept from collapsing by the pressure of the gas that it is made of. For white dwarfs, the pressure is provided by the constant motion of their electrons due to the quantum mechanical uncertainty principle. Chandrasekhar showed that no white dwarf can have a mass greater than about 1.4 times the mass of the Sun, a value now known as the Chandrasekhar limit. This result is important in astrophysics because of the consequences as a white dwarf star approaches the Chandrasekhar limit: the result is a catastrophic, thermonuclear explosion, the famous supernova, which destroys the entire star. A similar supernova explosion occurs when the iron core of a large star approaches the Chandrasekhar limit, only this time while the outer parts of the star explode, the core collapses to form either a neutron star or a black hole. A neutron star is an extremely dense object made almost entirely of neutrons with about the mass of the Sun and the size of a city. A black hole is an object that has undergone complete gravitational collapse and whose gravitational field has become so strong that even light cannot escape from it. Though Chandrasekhar's calculation is a fairly straightforward consequence of quantum mechanics, Eddington refused to accept it, gave talks in which he claimed that it must be wrong, and attempted to develop an alternative version of quantum mechanics in which there would be no limit to the mass of a white dwarf star. On the face of it, Eddington's behavior in this case seems arbitrary, dogmatic, and somewhat bizarre. However, Stanley points out that Eddington's stance makes sense when one recalls Eddington's style of doing astrophysics and the value of seeking that underpins that style. This style, which relies as much on intuition and inspired guesswork as on deductive mathematics, was invaluable in the early days of stellar models when much of the relevant physics was unknown. However, for the white dwarf problem, all the relevant physics was known, and there was little scope for Eddington's more freewheeling style, which in this particular case became counterproductive.

The question of values is fundamental to Stanley in his attempt to reconcile Eddington's science and religion. "Valence values . . . give us a new way to look for those points of intersection with common values in religion," especially in "situations where the sociocultural role in science is not obvious." And, furthermore, "A values-based approach to the history of science has the significant benefit of allowing exploration of the relationship between science and society without needing to decide a priori whether the physical world or the social world dominates" (239). One salient episode in the lives of Victorians which presented this issue of valence values was the 1865 Morant Bay (Jamaica) uprising, the infamous Governor Eyre controversy, in which excessive force was deployed to quell protesting blacks. The question of the day was whether the Governor's action was overreaction and a miscarriage of justice by the colonial government because a white defenseless minority (13,000) was perceived to be at the mercy of a largely black population (350,000), who, it was feared, might use the occasion to redress past wrongs, something Eyre himself admitted. The conflict polarized Victorians, some siding with Eyre and his no-nonsense, strong-arm tactics, and others demanding his prosecution for crimes against humanity. The Eyre Committee expended its energies and financial resources in the cause of an individual censured by his country for at least being responsible for a miscarriage of justice and for creating a climate that excited the reckless killing of approximately 500 blacks, the majority of them bystanders whose only guilt was being black. Indeed, the Eyre controversy raised a crucial imperial/values question. Interestingly, Eyre's supporters were mostly writers and declared humanists, such as Thomas Carlyle, Charles Dickens, Alfred Lord Tennyson, and John Ruskin. The sole scientist was John Tyndall, whose support came from loyalty to Carlyle. Eyre's detractors, on the other hand, John Stuart Mill, Charles Darwin, Thomas Huxley, and Herbert Spencer, emerged from the largely scientific community, whose curriculum of study, it was said, "tends to generate a narrow and bigoted belief in . . . the search after truths of all kinds" (T. H. Huxley). Yet it was they and not the humanists who pursued a course of justice, calling into question valence values along with enlightenment ideals.

Practical Mystic is a very thoughtful and well written book with an innovative approach to the subject it covers, and should be read by anyone interested in the issue of science and religion. In his conclusion, Matthew Stanley, a professor at New York University specializing in the history of science, makes a number of important observations. He finds that the way we conventionally think about science and religion come up short when we consider Arthur Eddington, whose life and work illustrate just where the two fields interact and don't interact. Values, Stanley concludes, make a difference in science, forming as they do a "bridge" between science and society. And, finally, "a biographical approach is useful for seeing and thinking about the development and function of a set of values" (243). In the case of the Eyre controversy, one perhaps has to tease out why it was that large groups of humanists and scientists took different sides and opposed each other. What is clear is that both groups held different values, coalescing, perhaps, around ideas of progress, change, development, open systems, even justice. But what is clear, to return to Stanley, is that values are a "mechanism by which the social works through the individual" (243). As such, we must undertake a search for those values, complex though they are, that work to lend some coherence to the complex issues of society. "Values, like the lines between stars, are invisible but essential" (245). It is perhaps fitting to end with one of Gerard Manley Hopkins's scientific riddles, his poem entitled "It was a hard thing." A Victorian Jesuit priest and poet, Hopkins (1844–1889) was a curious observer of science. He contributed four letters to *Nature*, three on curious halos and one on remarkable sunsets, the latter stemming from the violent eruptions on Krakatoa on 26 and 27 August 1883:

> It was a hard thing to undo this knot.
> The rainbow shines, but only in the thought
> Of him who looks. Yet not in that alone,
> For who makes rainbows by invention?
> And many standing round a waterfall
> See one bow each, yet not the same for all,
> But each a hand's breath further than the next.
> The sun on falling waters writes the text
> Which yet is in the eye or in the thought.
> It was a hard thing to undo this knot.

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