Of Principia and Particles – Ponderings in Paperback

What Makes Nature Tick?

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Roger G Newton
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'They who know do not speak', said Lao-Tse. Fortunately, the second half of this century has produced a crop of scientists who have cocked a snook at this piece of venerable wisdom by setting loose a veritable flood of illuminating commentary on a range of esoteric lore that had hitherto remained the privileged preserve of experts. Coming in this tradition, Newton's book offers a fascinating pot-pourri of themes from physical theory in a temporal sweep ranging from the *Principia* to gauge theory.

The book opens by paying mandatory devoirs to Greek science. That old reliable, Democritus, comes in for a curtain raiser with his atoms. With this formality out of the way, the author settles down to serious business. A word about the structure of the book: of the ten chapters, the first four – i.e. roughly the first half of the book – is devoted to classical physics, by which term we conveniently designate anything before 1905, the *annus mirabilis* of the three Einstein papers.

The first chapter is a leisurely trawl of topics that bear on the historical and philosophical underpinnings of modern science. A sampler: Is it possible to distinguish pure from applied science? Can beauty be made the arbiter of scientific truth? How does a scientific theory go beyond the aggregate of facts from which it is distilled? (In a supremely beautiful analogy Jean-Paul Sartre compared a scientific theory to a cord which runs through the pearls of fact). Is the dialectical threesome of *observation – theory – experiment* the sole paradigm of scientific reasoning? Why does the architecture of the external world allow itself to be understood in terms of mathematics?

The next four chapters present a ramble through some classical themes. In the first of these – 'Chaos and the ghost of Laplace' – the scene is set in the eighteenth century, when, with Laplace's and Newton's labours the new myth of mechanism is being born. When Laplace wrote '*La Mechanique Celeste*', he had reared a monumental edifice which, its superb sweep notwithstanding, reduced the dynamic harmony of the universe to a celestial ballet choreographed by the law of universal gravitation and determined for all eternity from its state at any instant. But the march of ideas finds curious ways of puncturing pride and this eighteenth century vision looks a bit tarnished now by the emergence of the theory of chaos.

Incidentally, the ensuing discussion may at times intimidate the mathematically underprepared, with its conceptual density,

especially in introducing ideas like the Hamiltonian, phase space and energy surface in a rapid fire staccato. (There is even a courteous nod in the direction of KAM theory). Confronted with this formidable machinery, how much effort could a reader be expected to invest in understanding it? (There is an apocryphal anecdote featuring Leo Szilard. A colleague, prior to embarking on a technical discussion, had asked Szilard precisely what could be assumed on his part. "Infinite ignorance and unbounded intelligence", replied the great man. Maybe, such a reader ...).

'Time's Arrow' surveys thermodynamics, especially its famous second law. The core of the discussion concerns the insidious mechanism by which a 'Time's Arrow', i.e. a direction for the flow of time, is introduced into the world. Unlike the other sections, the level of the discussion here rarely goes beyond the school final curriculum in physics. And this underscores one of the strengths of this book. By connecting entropy with disorder, for instance, we are led to irreversibility and the meaning of the second law in this context. Heady stuff for anyone who has been hand fed the classroom combination of routine calculations and the Carnot cycle. It is lively little forays like this that make the book an excellent supplement to more conventional text book material.

'Forces at a distance' is a dialogue on two new sciences – relativity and quantum mechanics, which were formalised as disciplines by 1930. The overthrow of classical physics and its supplanting by the weird rules of the quantum makes for a stirring narrative. But it is all necessarily heavy going. The treatment of some of the most advanced topics in the book can understandably come only with a heavy overlay of terminology that has obliged Newton to strew some fairly complicated ideas around, rather in the manner of a terrier shaking off fleas. It is difficult to escape this conclusion if we look at terms like operator, wave function, Dirac's equation, infinite energy, electroweak unification, GUT, gauge invariance, Yang-Mills theory, string theory, etc., liberally bandied about in the space of a few paragraphs.

The section on waves is probably the most demanding, mathematically. Beginning with the plucked string model of wave motion, the discussion transits rapidly through the partial differential equation which describes it and its solution in terms of sine and cosine functions, with their significance for higher harmonics. The spotlight then passes from vibrating strings to vibrating membranes and then to light and the standard wave behaviours like interference and the Doppler effect. In keeping with the general philosophy of the book, the power and reach of this fairly conventional material is demonstrated by two short essays – one on the Schrödinger equation and the other on solitons.

The following three chapters return to relativity and quantum mechanics. This time around, we are offered an alternative perspective – the strongly counter-intuitive cultures of these two great systems on the one hand and their extreme mathematical sophistication on the other. Relativity

knocked the stuffing out of intuition by the strange alchemy by which it welded space and time into the architecture of the universe – and its consequences like time dilatation and the twin paradox. But it was left to quantum mechanics to do the demolition job on naïve realism – which it proceeded to do methodically in a series of bizarre footnotes like the uncertainty principle, the superposition of states and the EPR paradox. ("Whoever is not shocked by Quantum Mechanics has not understood it", said Bohr).

"It has long been an axiom of mine", observed the immortal detective of Baker Street, "that little things are infinitely the most important". Roger Newton would surely agree. In a chapter devoted to the 'little things', he has created a portrait gallery of the particle zoo. The fermions, bosons, tachyons and baryons are all there, along with some more exotic species. As for the parlour games the little things can get up when they decide to party, Newton presents a discussion on magnetism, superfluidity and superconductivity from the molecular standpoint. The last short chapter looks at the profound role played by symmetry in unifying physical phenomena at their deepest level and the consequences of symmetry breaking. An excellent bibliography rounds off the account.

The book's Americanisms (an approximation is a 'ballpark estimate') and its preoccupation with political correctness (witness its curious solution to the issue of gender specific pronouns), should add a piquant cultural flavour for readers outside the States. Beyond these and the occasional and almost inevitable obscurities bred by the nature of the undertaking itself, lie the invincible merits of the book. And there should surely be enough of these to ensure its enthusiastic reception.

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Algebra in Ancient and Modern Times

K B Sinha

Algebra in Ancient and Modern Times
V S Varadarajan
Hindustan Book Agency
Trim series #14,
New Delhi, 1997, pp. 159

This is a wonderfully well-written book by an outstanding Indian mathematician and is delightful to read. The author has achieved a most difficult task – making the material accessible to the expected readership (final year in school/first year in University) and yet at the same time keep alive a sense of history.

The presentation is chronological, beginning with Pythagoras, Archimedes and Euclid and their geometry, interweaving his account with various facts about numbers and their properties, with a brief excursion into Diophantine problems (in particular the