liberated themselves to some extent from this shabby world are not giving pleasure to each other'.

What a noble and gentlemanly way of ending a controversy over an important issue of priority!

It is well known that Einstein had a half-century-long struggle with the quantum of light. In desperation in 1951 he wrote be Besso, 'The whole fifty years of brooding [Gr *ü* belei] have not brought me nearer to answer the question "what are light quanta"...'.

In Part VI, Stachel gives a historic account of this struggle beginning with the controversy on the Bohr model and proceeding to the complication of the wave–particle duality, the role of the observer in quantum mechanics, the EPR dilemma and the reconciliation of gravitation and quantization. The longstanding discontent with quantum mechanics is evident from the statement that Einstein made at the Solvey Congress of 1911:

'We are all agreed that the so-called quantum theory of today is indeed a useful tool, but no theory in the ordinary meaning of the word, at any rate not a theory that could now be developed in a coherent manner. On the other hand, it has been proven that classical mechanics, ... as expressed in Lagrange's and Hamilton's equations no longer can be regarded as a usable system for theoretical representation of all physical phenomena ... . So the question arises: on the validity of which general principles of physics, may we hope to rely in the field of concern to us [i.e. quantum phenomena]'?

In the section on 'Einstein and quantum mechanics'. Stachel comes to the interesting conclusion '... After 1930, Einstein never denied the great explanatory power of quantum mechanics, nor challenged its validity; but he did not agree that this success required the acceptance of the underlying conceptual structure as the basis for all further progress in theoretical physics'. In 1954, Einstein wrote to Besso, 'I consider it entirely possible that physics cannot be based on the field concept, that is on continuous structure. Then nothing will remain of my whole castle in air, including the theory of gravitation, but also nothing of the rest of contemporary physics'.

In Section VII, Stachel has made a comparison between Einstein and other great scientists like Newton, Eddington, Infeld, Lanczos and Bose, who did their monumental works in quite different environments, opportunities for learning and researching. Stachel comments that while Newton created the mathematics necessary to develop his ideas about mechanics and gravitation, Einstein, though an able pupil and practitioner, was never really creative in mathematics. Eddington, who was also a relativist and cosmologist, had interactions with Einstein at various points of time. However, each regarded the other as dogmatic and inconsistent on their cosmological theories. The equally long section on Infeld, the author of the famous book *Quest*, a student of Einstein and a long collaborator, gives an indepth account of the struggle of scientists from countries like Poland, who had to face the Nazi oppression on Jews. Though Einstein was not happy with the publication of *Quest* and chastised Infeld for some of its contents, he still says at the end of his letter '... Now since it has happened, don't have too many afterthoughts. It is meritorious to pitilessly expose wrongs and mendacity. And the grass grows quickly on what has already happened, especially in America'.

The Hungarian physicist Lanczos, who worked in the areas of relativity, field theory and cosmology, was another scientist from Eastern Europe who interacted with Einstein from the 1920s. What is revealing is a letter which Einstein wrote to Lanczos in 1935. '... I am interested in your publication, but cannot understand how as a Jew you still publish in Germany. This is really a sort of betrayal. The German intellectuals have behaved disgracefully in connection with all the dreadful injustices and have richly merited being boycotted. If foreign non-Jews don't do it, that is sad enough.'

The last article in this section is on S. N. Bose, whose derivation of Planck's law is described by Abraham Pais as 'the fourth and last of the revolutionary papers of the old quantum theory'. It is this paper that primed Einstein to exploit its implications to quantum theory of ideal gas and also recognize the limitations of the old quantum theory. The article summarizes succinctly the historical facts relating to the manner in which interaction developed between Einstein and Bose. This account of Stachel removes much of the confusion that exists between the relative roles of Einstein and Bose in the formulation of the Bose–Einstein statistics.

One of the chief merits of this book is the authenticity it brings to the views expressed by Stachel and others on Einstein and his works, by giving extensive references to the related matters in books, letters and publications. It is a must for every scientific library, to all who are interested in the historical development of theoretical physics in the 20th Century, particularly on relativity, quantum mechanics and cosmology. The book has profuse information on many aspects of Einstein's early years that are not available in other books. It has a flavour that is appealing to the young and old, to newcomers to the field of physics and cosmology, and also to mature scientists who have studied in depth relativity and quantum mechanics. The quotations from Einstein on many aspects of life and human relations are particularly enthralling.

For completeness, Stachel has also included his reviews on the two books, *Subtle is the Lord: The Science and Life of Albert Einstein* by Abraham Pais, and *Albert Einstein: A Biography* by Albert Fösling.

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The Extravagant Universe. Robert P. Kirshner. Princeton University Press, 41 William Street, Princeton, NJ 08540, USA. 2002. 282 pp. Price not stated.

Visitors to the Giant Meterwave Radio Telescope, after having spent half an hour or more exhausting their curiosity regarding black holes, the big bang, extra solar planets and extra-terrestrial life, almost invariably ask some variant of the following question. 'Don't you think it is a waste to spend all this money building a telescope?'. Why is it that a society that has a great deal of curiosity about its cosmic origins, finds it a waste of time to seriously investigate these issues? The conviction that 'science' has to be focused on the mundane is not particular to the post-colonial Indian middle class. Towards the end of the book under review, Robert Kirshner describes a meeting where several ex-advisors to the President of the United States spoke about the role of science in the US. They droned on about 'the value of science for national defence. Science as the golden goose. The value of science to cure diseases and increase the span of human life', to an increasingly restless Kirschner. Kirshner felt that 'the science of the universe is not aimed at creating wealth, improving defenses, or curing diseases. It is aimed at increasing our understanding, and nobody on the platform was talking about that.' The book under review is perhaps an outcome of Kirschner's irritation, and is aimed at increasing the general public's understanding of the cosmos, and the manner in which humans with 'little brains and brief lives', can nonetheless 'build a rational picture of the universe.'

The questions that Kirshner sets out to answer are the three fundamental ones that most of us have probably asked at some point or the other (most likely, 'in a penetrating tone from the back seat of the family car') viz. 'Where are we?' 'What time is it?' and, 'When do we get there?' Surprisingly enough, the answers come, (in part) from research into a seemingly unconnected topic, that of how stars grow old and die as supernovae.

As a beginning graduate student at Caltech, looking for a thesis topic, Kirshner was handed a bunch of photographic plates on which were recorded the spectra of various supernovae, and sent off to make sense of them. In the fine old tradition of Caltech, the data had been 'ripening like fine wine' in the desk of his thesis advisor, waiting for the right time (and willing graduate student) to take a look at it. Supernovae are brief moments of glory marking the death of particular types of stars. For the few weeks it lasts, a supernova can be as bright as all the remaining stars in the galaxy combined. Supernovae are also gigantic nuclear factories, where heavy elements are cooked out of lighter ones, and then spewed out into the interstellar medium. Here, these atoms go on to form dust grains, then planetesimals, then planets, before (for some of them at least) finally ending up being made into wedding rings, Cartier watches and atomic bombs. But despite this large measure of cosmic significance, the study of supernovae spectra has (as Kirshner himself admits) more than a whiff of philately about it. In fact, as an undergraduate, spectral classification was one of three astronomical pursuits that Kirshner was determined to avoid at all costs. Ironically enough, as he details in the book, in the course of his career, he ended up being forced to wrestle with all of them.

To understand what supernovae have to do with the three fundamental questions for all ages (if not all times), we too will need to get our hands a little dirty with the philately of spectral classification. It turns out that there are supernovae and then there are supernovae. The ones that we are particularly interested in are those that have been imaginatively called type Ia (because they were discovered before supernovae of type II, which in turn were discovered before those of type Ib). Supernovae of types Ia and Ib, both show no lines from hydrogen in their spectra; the difference between types Ib and Ia is that spectra of type Ib have strong lines of oxygen and calcium, while those of type Ia do not. On the other hand, type Ib supernovae are produced by a process similar to that which makes type II supernovae, and different from the one by which supernovae of type Ia are made. Perhaps, you can now empathize with the young Kirshner's antipathy for spectral classification. Anyway, to get back to the topic at hand in supernovae of type Ia, we start by noting that isolated stars like the sun end their lives not by blowing up as supernovae, but rather by becoming tiny dense objects called white dwarfs. White dwarfs have no nuclear reactions going on inside them, and as time passes, they cool down and gradually fade away. Classical physics cannot explain why, despite lacking an internal energy source, these cold stars do not collapse under their own gravity. It can be understood only by using quantum mechanical principles, and it is for this application of quantum mechanics to stellar structure (which also resulted in the prediction that the maximum mass that could be supported from collapse in this way is 1.4 times the mass of the sun – the 'Chandrasekhar limit') that Chandrasekhar got the Nobel Prize. However stars, (unlike humans), tend to be born in groups, and binary stars are not uncommon. In a binary stellar system where one star has already become a white dwarf, the intense gravity of the white dwarf results in matter being sucked from the companion star and onto the white dwarf. The white dwarf increases in mass till it reaches close to the Chandrasekhar limit, at which point it explodes as a supernova~Ia. Since supernovae of type Ia all result from stars close to the Chandrasekhar limit, one might expect all supernovae~Ia to have similar intrinsic brightness. Careful observations by Kirshner's group show that this expectation is in fact, close to (but not exactly) the truth. Supernovae of type Ia vary slightly in brightness. It turns out, however, that this can be corrected. Given this correction (the determination of which took years of effort by Kirshner's group and others), one can figure out how bright a given supernova in a distant galaxy actually is, and can measure how bright it appears to be and can therefore calculate the distance to the galaxy. From the spectrum of the supernova one can also measure how much the universe has expanded from the time the supernova went off to the time the light it emitted reached the earth. In astronomical jargon, this is termed as the redshift. The relationship between the redshift and the distance to a given object depends on the rate at which the universe has been expanding in the past. By carefully measuring the brightness and spectra of these distant supernovae, one can therefore work out the evolution of the expansion of the universe. Prior to the supernovae work, the general belief was that the expansion of the universe should be slowing down with time. However, supernovae~Ia turn out to be slightly dimmer than they would be in such a universe, and instead require the expansion of the universe to be speeding up with time.

Why should the expansion of the universe speed up or slow down with time? Or indeed why should the universe be expanding at all? Models for the evolution of the universe are based on Einstein's general theory of relativity. In Einstein's time, it was generally believed that the universe was static, i.e. not expanding or contracting, whereas the general theory of relativity did not naturally produce a static universe. To keep the universe static, Einstein added a constant to his equations, (the 'cosmological constant'), whose value was chosen such as to balance things out and keep the universe static. Shortly thereafter, however, observations established that the universe was, in fact, expanding, and that the cosmological constant was not necessary. Astrophysicists have, ever since regarded the cosmological constant ('Einstein's biggest blunder') as an embarrassment at best and 'theoretical poison ivy' at worst. But the universe is, as Kirshner says, an extravagant place, stranger than our wildest dreams. It turns out that to produce an accelerating universe one does require a cosmological constant, or something very much like it. Excepting, this time, the value of the constant is such that instead of keeping things static, it speeds up the expansion. Of course, to be certain that what the observations point to is a cosmological constant, one needs to understand supernovae~Ia well. Perhaps, there is no cosmological constant, but instead distant supernovae are just different (and dimmer) from nearby ones. Perhaps, there is some obscuring material between them and us which makes the supernovae appear dimmer. Or perhaps, with your distaste for philately, you have got supernovae of different types (and hence different intrinsic brightness) adulterating your sample. Kirshner's book gives a cogent and interesting account of why it is unlikely that the data are affected by issues of this sort.

In his *Hitchhiker's Guide to the Galaxy* trilogy, Douglas Adams suggests that every major culture goes through three distinct and recognizable phases; those of survival, inquiry and sophistication, otherwise known as the how, why and where phases. For instance, the first phase is characterized by the question, 'How can we eat?', the second by 'Why do we eat?', and the last by 'Where do we have lunch?'. In this scheme, the subculture of popular science aficionados should surely be classified as having reached the sophistication phase. One needs to go beyond describing natural phenomena and offering explanations in accessible terms. Recognizing this, Kirshner, throughout the book, but more so in the latter half, writes also about the real politik of modern astronomy. What happens when two major groups decide to work on the same project? Particularly, when the leader of one group is on the advisory board of the other?

Kirshner leads us through the feints and thrusts of conference talks and referee reports. The subtle and not-so-subtle put-downs at seminars. Issues of priority and credit. The agony and the ecstasy of deciding between whether to rush into print (and risk the danger of being wrong) or to wait for more confirming data (and risk the danger of being scooped). But through all this hurly-burly, it is clear that Kirshner has had a great deal of fun with this project, and that comes through in the book. The prose is vigorous, the tone is lively, the style is amusing. Go read it.

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A History of Hindu Chemistry. Vol. I and II, Centenary Edition. Acharya Prafullachandra Ray. Somnath Bal, 86/1 Mahatma Gandhi Road, Kolkata 700 009. 2002. 152 pp. Price: Rs 1050.50.

There is a verse in the *Chandyogya Upanishad* (IV, 17, 7) which states: 'As one binds gold by *lavana* (borax), silver by gold, tin by silver, lead by tin, iron by lead and wood by iron and also by leather… .' The verse is indicative of the status of materials science of the Hindus even in the days of the *Chandyogya Upanishad*, which belongs to the 8th/7th Century BC (at the latest). Several scientific works of this period, such as *Rasaratnakara*, *Rasarnava*, *Rasaratnasamuchchaya*, *Kakachandeswari*, *Rasendrachudamani* and *Rasaprakasasudakara*, describe the practical expertise of the Hindus in such aspects of materials science as calcination, sublimation, distillation, steaming, fixation, etc. *Rasarnava* describes different *yantrams* (instruments) for these operations. The Hindus were also aware of alkaline and acidic materials and that on mixing, they get neutralized. *Rasarnava* mentions a mixture called *Vidas*, which has the property of the aqua regia!

The material prosperity of the Hindus would not have been possible without centuries of development in materials science (chemistry in particular, although not in the way the subject is understood today), even before the Buddhist era. Among the metallurgical skills of the Hindus may be mentioned tempering of steel in a manner worthy of advanced metallurgy and forging a bar wrought-iron pillar (which is close to Kutab Minar, AD 400) larger than any that had been forged even in Europe up to a very late date. Pliny is reported to have stated that the best glass ever made in those days was Indian glass.

In the book under review, the author Acharya Prafullachandra Ray refers to an interesting method of characterization of metals in those days, copper by blue flame, tin by pigeon-coloured, lead by pale tinted, iron by tawny, peacock ore (*sasyaka*) by red (cf. the flame test of present-day analytical chemistry).

The central theme in this book is to establish that the developments in materials science (chemistry) and also in medicine in Hindu India were indigenous. Ray lists a number of works on the subject by Charaka, Sasruta, Vagbhata and others of the pre-Buddhistic era, which have been translated for the Caliphs of Baghdad around the 8th Century. Charaka occupied a place of honour in the library of a cultured Arab. Ray mentions that several Hindus were induced to reside at the court of the Caliphs, as their instructors. Mussalman students, in turn, flocked to the centres of learning in India.

A point of great importance, that Ray makes, is that 'between the period of the *Atharva Veda* and the days of Charaka, there must have been composed several medicinal treatise. Charaka represents only a more or less final development'. At the time of Charaka there existed at least six standard works of Agnivesa, Bhela, Jatukarna, Parasara, Harita, and Ksharapani.

The truth is that till pseudo-Basil Valentine (ca. AD 1600) very little scientific progress was achieved in Europe. On the other hand, the Hindus had the concept of atoms (*anus*) from the early days. Materials were considered as aggregates of *anus*. Kanada maintained the eternity of the *anus*. Ray has an intriguing discussion on *Parimandalya*, a term which indicates a spherical shape (vol. 1, p. 211).