Homi J. Bhabha – Architect of Nuclear India. Dilip M. Salwi. Rupa & Co, 7/16, Ansari Road, Daryaganj, New Delhi 110 002, 2004. 68 pp. Price: Rs 195.

The author of this slim book, a noted science writer, Dilip M. Salwi died on 2 April 2004, at a relatively young age, following a heart attack. He was 52. 'A postgraduate in astrophysics from Delhi University, Salwi authored more than 50 books. He made it to the *Limca Book of Records* for two consecutive years – 1998 and 1999. On the first occasion, his name was included for his science fiction *Fire on the Moon*, which sold more than three lakh copies. The second time, it was for writing the largest number of popular science books for children. Salwi was also a recipient of several awards'.

To write a review of one of Salwi's books posthumously, may not be quite appropriate. However, taking a dispassionate view on the technical content of the book is pardonable.

A biography of Homi Jehangir Bhabha had been written earlier on, in 1994, by yet another popular science writer and an eminent scientist, G. Venkataraman. That book is titled *Bhabha and his Magnificient Obsessions*, published by Universities Press in their series *Vignettes in Physics*. Salwi had the benefit of referring to this book, as it is listed in his bibliofile. There is yet another biography namely, *Homi Jehangir Bhabha* by Chintamani Deshmukh, published by DK Agencies Pvt Ltd, New Delhi, 2003; I have not gone through that book.

Venkataraman's book runs over nearly 200 pages. Contentwise, that book is complete, to say the least, interspersed with physics at an elementary level and contains many original quotes, samples of copies of original letters, etc. Compared to Venkataraman's book, Salwi's appears superficial technically; the plus point is that the book has some good photos in black and white and in sepia.

I found one major error that needs to be corrected, if there are going to be reprints, namely the caption to the photograph on p. 39 should have been 'Bhabha discussing in front of a model of Apsara Reactor' rather than 'Bhabha demonstrating an experiment before young physicists'. On p. 22, Salwi notes 'Through his family ties with the Tatas, he (Bhabha) secured a Special Reader's post at the Indian Institute of Science at Bangalore'. On this, Venkataraman's book (p. 6) notes 'In September 1939, Bhabha was in India on what he intended to be a short holiday but the war changed his plans . . . A few universities made an offer – I believe Allahabad and Calcutta were among these. Finally Bhabha accepted the offer of Readership from the Indian Institute of Science . . .'. So how effective were the 'family ties' in securing Bhabha a job is questionable, especially in view of his education and experience. Other personal aspects of the life of Bhabha have also come in greater detail in Venkataraman's book. For example, the story of election of Bhabha as a Fellow of the Royal Society, nominated by C. V. Raman and seconded by Paul Dirac, is succinctly given (p. 8) therein, whereas Salwi lists it as one of the milestones in Bhabha's life.

The book could have listed *Homi Jehangir Bhabha: Collected Scientific Papers*, edited by B. V. Sreekantan, Virendra Singh, and B. M. Udgaonkar (Tata Institute of Fundamental Research, Mumbai; 1985) in its bibliofile.

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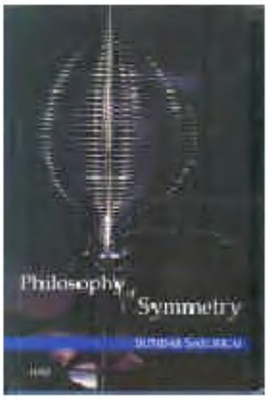

Philosophy of Symmetry. Sundar Sarukkai. Indian Institute of Advanced Study, Rashtrapati Nivas, Shimla 171 005. 2004. 167 pp. Price: Rs 250.

As Herman Weyl said in his Louis Clark Vanuxen lecture at Princeton University in 1951, 'Symmetry, as wide or as narrow as you may define its meaning, is one idea by which man through the ages has tried to comprehend and create order, beauty and perfection'. In common parlance, as certified by *Roget's Thesaurus*, the concept of 'symmetry' is associated with concepts of 'equality, order, conforming, centrality, regular form, style, and beauty'; 'lack of symmetry' is associated with 'ugliness' and adjectival 'symmetrical' with 'rule'. When we include technical discussions of the applications of the concept of symmetry in science and arts, as opposed to common parlance, the list of associated concepts gets considerably enlarged. Sarukkai, in the introductory part one of his book *Philosophy of Symmetry*, lists a set of fourteen key terms connected with the concept of 'symmetry'. These are property, conserved properties, casual role, transformations, invariance, law, symmetry principles, mereology, criterion for kind (as ordering), proportion, harmony and balance, perception, epistemology, and aesthetics. Such a wide-ranging concept as symmetry clearly calls for a philosophical analysis and this is what the author proposed to carry out in this book.

Symmetry plays a profound and extensive role in modern physics. It was not always so. Though Newtonian physics was invariant under the group of Galilean transformations, it was not something which was made much use of. The invariance of Newton's equations of motion under these transformations does not give rise to the ten classical laws of conservation of motion. The invariance of the Lagrangian under these transformations is needed for that. The full set of the ten conservation laws was first derived through symmetry considerations by Herglotz in 1911, and the general relationship between conservation laws and invariance principles was worked out by Emmy Noether in 1918.

Symmetry considerations in classical physics were more successful in crystallography. The three-dimensional Euclidean space looks featureless. It is unchanged under translations and rotations. Yet symmetry consideration tells us that there cannot be more than five types of regular solids (i.e. Platonic solids) in it, and it cannot tolerate more than 32 kinds of crystals provided the crystal lattice is left invariant. It does not matter as to which atoms they are made of. The featureless container, i.e. the Euclidean space, puts restrictions on what it can contain. The use of symmetry here is in the classification of all crystals in 32 crystallographic classes and is responsible for the existence of that subject. Pierre Curie, around 1908, was among the first to use symmetry consideration in discussing various physical properties of crystals.

With the advent of special theory of relativity proposed by Einstein in 1905, the symmetry considerations in physics took centrestage. They are no longer secondary. Einstein proposed the Lorentz group, or if we also include translations, then the Poincaré group, of transformation of space-time as the fundamental geometric symmetry group of nature.

The equations of Maxwell's theory of electromagnetism were already invariant under Lorentz group of transformations, and they did not need any change. Newton's equations of dynamical motion of point particles had to be suitably modified and this resulted in the famous $E = mc^2$, the only equation to feature in Bartletts Familiar Quotations. Now that Newton's equations were brought in harmony with Maxwell's equations, it also became clear as to why all the experiments to detect the motion of the earth through luminiferous ether had given a null result. Symmetry was being used to fix the laws of nature.

Symmetry conditions are even more powerful in a quantum-mechanical context. Why is that so? As pointed out by Wigner and Yang, this is because the state space of quantum system is a linear space.

The main, though not exclusively, philosophical considerations about symmetry in science are metaphysical in nature. They take up about half the book under review and are discussed in part two, 'metaphysics of symmetry'. They are grouped in five heads, viz. (i) Objects, (ii) Sets, Groups and classes, (iii) Change, (iv) Property, and (v) Conservation laws and conserved properties.

One discusses symmetry of various objects. The objects can be concrete (e.g. a book) or abstract (e.g. a number). Is this a distinction between those objects which exist in space-time and those which do not? Following Lowe, one can either take a semantic or a metaphysical approach. In the metaphysical approach, any entity which possesses 'determinate identity conditions' can be regarded as an 'object'. In the semantic approach, the set of entities to be regarded as objects is much wider, e.g. 'grin' is also an object in this view. If we include a consideration of 'determinate countability' (dc) in addition to that of 'determinate identity condition' (dic), then entities can be of four finds: (i) objects (e.g. a tree), have both dc and dic, (ii) quasi-objects (e.g. quantum particle) have dc but not dic, (iii) quasi-individuals (e.g. mass and energy) have dic but not dc, and (iv) non-objects (e.g. the particular sphericities of individual spherical objects) have neither dic or dc. Entities which are not objects, e.g. quantum particles, even though not possessing 'objecthood' do exist. Both particulars and universals can be objects.

For concrete objects, e.g. bilateral symmetry of a horse, one discusses the symmetry of its form. The same can be done for abstract objects, e.g. rotational symmetry of a circle. For concrete objects the shape is regarded as a first-order property, and we also make a distinction between matter composing this object and its form. This is not so clear for abstract objects. Here symmetry can be used to define the form and seems to be a primary property. It is, however, not clear, and is probably incorrect except as an approximation, that an irregular form can be viewed as a 'sum' of regular forms.

It seems that in the quantum world the concept of symmetry is more basic than that of objects. Wigner, in 1939, gave a classification of quantum particles using irreducible representation of Poincaré group. In fact, Bohr and Ulfbeck have tried to argue that the quantum world is a primary manifestation of symmetry (*Rev. Mod. Phys*., 1995).

Group theory provides the main mathematical object used in a discussion of symmetry. Groups are sets of its elements with a specified rule of composition for any two of these elements to give another element. They also have a closure property and an identity element. Sets can be composed for almost any set of elements. But groups are very selective in their memberships. Groups also exemplify that 'not all classes have to be fusions of singletons', except in the case of Abelian groups. The metaphysical problems related to sets, groups and classes are discussed next.

Since symmetry in science is related to invariance under change, it is necessary to discuss metaphysical aspects of change in its varied ramifications. A broad criterion of change is as follows: If there is an object x and a property P, and if the object x has property P at a time t and it does not have the property P at a different t', then we can say that there is a change in the object x. Should we, however, restrict to nonrelational changes? A person becomes an 'uncle' at the birth of his nephew. This is a purely relational change for the person. The changes in property P also cannot be arbitrary. A green leaf changes to brown. So changed property is of the same kind. Lombard uses the word 'contrary' property in this context. It would be better to say that there is a spectrum of values of the property P and the object x takes a different value in the spectrum of P. In the discussion on change and symmetry, it would have been nice to have introduced Wigner's distinction of active and passive points of view while considering transformation. There is nice discussion of invariance and its relationship to change.

Our discussion of change involved talking of properties. In fact, it is argued that symmetry itself is a property. So we say that 'invariance of the shape of the rubber balls under deformation' is what we call symmetry. But 'invariance of the shape of the rubber ball under deformation is nothing but a description of a property of the rubber ball…, called elasticity'. Some of the subsections such as 'Shape or symmetry? A lesson from physics'; 'Symmetry as first order property; 'An analogy from motion', etc. are nicely argued.

The relationship between conservation laws and conserved properties is discussed next (we have briefly touched on it earlier). The distinction between global symmetries of a Lagrangian which give rise to conservation laws, and local symmetries such as gauge-invariance or general coordinate invariance, which do not give rise to such conservation laws but fix the dynamical laws of motion, would have been worth discussing here. A discussion of broken symmetry versus spontaneously broken symmetry was also called for.

We now come to a discussion of symmetry in art. Unlike science, the relationship here is problematical.

One can point to numerous examples of the use of symmetry in Greek sculpture, especially bilateral symmetry. In architecture, the golden ratio has played an important role. Among the 17 two-dimensional ornamental groups, 14 have been used in decorations at Alhambra in Granada. In Indian art, the famous Nataraja image has many elements of symmetry. So do various *cakras* and *yantras* that are used as aids to meditation. Similar examples can be given from other cultures. Yet extreme symmetry in composition does not result in beautiful art. Music in which the same note is played again and again would be boring. The main role of symmetry in art is in maintaining correct proportions and measures. In Western music, we refer to harmony.

The main considerations in a philosophyical analysis of symmetry in art are related more to phenomenology and aesthetics than to metaphysics. These are taken up in the third part of the book.

As has been known, we suffer from a 'hegemony of vision'. So a discussion of

'Phenomenology of perception' provides a starting point. Even shapes and sizes of objects we perceive depend on our perspective. There is an 'optimum distance' for viewing things. Even in this, a sense of balance is involved. Also involved is our past exposure to the objects viewed, i.e. sedimented knowledge. So how do we perceive symmetry? This takes us next into a discussion of relationship between 'Form and Vision'. The Gestalt's laws of perception are taken up. A certain intriguing relationship between Gestalt's laws and group theory is then pointed out. Closure property of groups and a closure property, where perception fills in the gaps and missing elements in the Gestalt theory of vision are seen to be parallel. Identity operation in group theory is likened to the Gestalt principle of 'unity of perception', and so on. The rest of the discussion is basically about symmetry and aesthetics relationship. Yet in arts we cannot but agree with the Chinese Tehyi Hsieh, 'Harmony would lose its attractiveness if it did not have a background of discord'.

By its very nature, the discussions in philosophy, even of symmetry, do not come to final conclusions. Still I wonder whether the author should have attempted a synthesis of metaphysical and phenomenological analysis of symmetry as the last part of the book. However, these discussions sharpen the perception of the problems involved in the concept of symmetry. The cover of the book is beautifully illustrated by the photograph of a sculpture entitled 'Valampiri Shankha'. The book is recommended to all those involved with various aspects of symmetry.

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Erratum

Occurrence of xenotime in the Narasapur beach placers, West Godavari District, AP

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(*Curr. Sci*., 2004, **87**, 1458–1461)

In reference number 6, the last author should read as Sankaran, R. N. instead of Sankaran, A. V. The error is regretted.

— Editor