author (three of them with coauthors), as well as two papers he posted on arXiv.

References

Alpher, R.A., and Herman, R., 1948. Evolution of the Universe. *Nature,* 162, 774–775.

Burbidge, E.M., Burbidge, G.R., Fowler, W.A., and Hoyle, F., 1957. Synthesis of the elements in stars. *Reviews of Modern Physics*, 29, 547–650. [Often referred to as B^2FH.]

Dicke, R.H., Peebles, P.J.E., Roll, P.G., and Wilkinson, D.T., 1965. Cosmic black-body radiation. *Astrophysical Journal*, 142, 414–419.

Eddington, A.S., 1917. Karl Schwarzschild. *Monthly Notices of the Royal Astronomical Society,* 77, 314–319.

Lemaître, G., 1931. A homogeneous universe of constant mass and increasing radius accounting for the radial velocity of extra-galactic nebulae. *Monthly Notices of the Royal Astronomical Society,* 91, 483–490.

Livio, M., 2011. Lost in translation: mystery of the missing text solved. *Nature*, 479, 171–173.

O'Raifeartaigh, C., McCann, B., Nahm, W., and Mitton, S., 2014. Einstein's steady-state theory: an abandoned model of the cosmos. *European Physical Journal H*, 39, 353–367.

Penzias, A.A., and Wilson, R.W., 1965. A measurement of excess antenna temperature at 4080 Mc/s. *Astrophysical Journal*, 142, 419–421.

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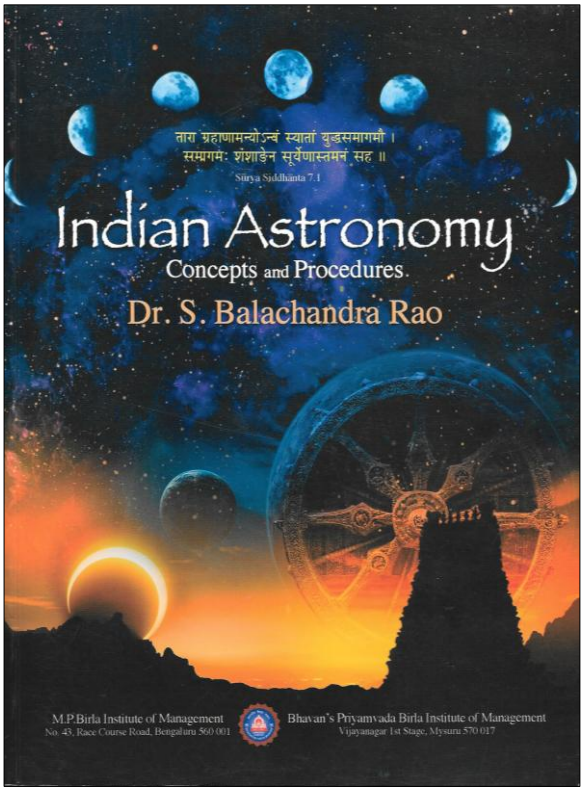
***Indian Astronomy: Concepts and Procedures*, by S. Balachandra Rao (M.P. Birla Institute of Management, and Bhavan's Gandhi Centre of Science and Human Values, Bengaluru, 2014), pp. [xiv] + 332. No ISBN (paperback), 180 × 240 mm, US$45.**

Indian astronomy stands apart from astronomy of other cultures due to its emphasis on precise calculations of motions of transient objects in the sky rather than discussions of stories and myths of constellations and zodiacs. Like most other cultures, it originally began with the realisation that twelve full moons brought the Sun close to its original zodiacal sign and hence twelve months make (nearly) a year—with a shortfall of 11 days. It therefore developed a concept of two intercalary months to be added to the lunar calendar every 5 years to synchronise the luni-solar calendar. This period was called a *Yuga* which was expanded significantly in later literature.

Since the exact time of the year and day was important for several ancient rituals, this initial arithmetic went on to take a complex root and the *Panchanga* or Indian almanac was born. *Panchānga* literally means 'having five limbs'. The five elements are:

(a) The *Tithi*, which is the time taken by the Moon in increasing its distance from the Sun by 12°. Since the motions of the Sun and Moon are always varying in speed the length of a *tithi* constantly alters;
(b) The *Nakshatra*, which marks the path of movement of the Moon. In one synodic revolution, the Moon travels through 27 stars fields that were said to form the 27 *Nakshatras* (lunar mansions);
(c) The *Vara*, or day of the week;
(d) The *Yoga*, the period of time during which the distance between the Sun and Moon is increased by 13° 20′ (~1 day); and
(e) The *Karana*, is half the *tithi*¸ during which the difference of the longitudes of the Sun and Moon is increased by 6°.



While the first three units are still in use, *Karanas* and *Yogas* are hardly used in day-to-day life.

Different aspects of these early concepts are found in some of the early astronomy, and *Tithi* and *Nakshatras* can be found in the earliest text of the *Vedanga Jyotisha* (the component of astronomy to the Vedas), which dates to about 1,000 BC. This text includes details of how to calculate solstices and other parameters that were needed for various rituals.

Since then works like the *Surya Siddhanta* (which dates to around 600 BC) significantly advanced our understanding of the skies. The *Surya Siddhanta* gives the method that should be used to determine the true motions of the

planets, the Sun and the Moon. It gives the locations of several stars other than the *Nakshatras*, and it explains how to calculate the occurrence of solar eclipses as well as the solstices. The Earth's diameter and circumference also are given. Lunar eclipses, and the colour of the eclipsed portion of the Moon, are mentioned.

Building on this, Indian astronomers went on to define a complete coordinate system, and make precise calculations of the true motions of the Sun, the Moon and the planets, including occultation of stars. The mathematics they evolved for this was based on algebraic equations that needed sine and cosine functions for which reference tables were created. These calculations also needed accurate synchronisation with observations. The complete methodology and procedure was formulated around AD 500 by Aryabhata.

The methods of calculation are unique and interesting and give very accurate results for the period during which they were computed. They are of great significance to historians of Indian and world astronomy. Unfortunately there are very few well-written and concise books giving details of the methods of computation in English which can be easily accessed by a student who is new to this field. Dr Balachandra Rao has tried to fill this gap.

Rao is a very distinguished researcher in the mathematical subtleties of Indian astronomical calculations, and he has written several books on various aspects of astronomical calculations in ancient Indian texts. The present tome is designed as a text book for students of Indian astronomy, and it explains several aspects of these calculations in a systematic manner with examples and explicit solutions to several problems to help a student understand the complete intricacies of the working of the mathematical aspects of Indian astronomy.

The only problem with this book is that it gives a complete coverage of Indian mathematical astronomy without providing finer historical markings. The history of the subject is only covered in the first few pages, and the book then gets down to explaining various subtle terms used in these calculations and their context. This emphasis is made clear by the subtitle of the book: *Concepts and Procedures*. The book takes great care to refer most of the terms used in Indian astronomy to modern or English terms, and therefore is an excellent introduction for a student desirous of understanding how to calculate various astronomical terms. It will prove invaluable for this purpose alone. While discussing the calculations, Rao continues to use Indian terms, so a glossary of Sanskrit terms and (where possible) English translations would have been very useful.

This book is even more significant for scholars in its attempt to exhaustively cover all aspects of calculations that can be undertaken. The book has discussions on calculations of transits of Venus and Mercury, and occultations of stars and planets by Moon. It also discusses the evolution of the methods of calculation to improve the process of calculation over time. All this makes the book one of the finest for students who wish to learn astronomical calculations in ancient India.

In conclusion, Rao has produced an excellent and a very readable treatise on the concept and procedures used in Indian astronomical calculations and this will provide a very useful guide to all students wishing to learn about the subject.

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***Lost in the Stars: A.W. Roberts at the Crossroads of Mission, Science, and Race in South Africa 1883–1938*, by Keith Snedegar. (Lanham, Lexington Books, 2015), pp. xii + 189. ISBN 978-0-7391-9624-3 (hard cover) 978-0-7391-9625-0 (electronic), 160 × 234mm, US$80.00.**

This is the biography of a remarkable person who, though well-known to South African historians for his political work, deserves to be remembered worldwide for his astronomy. By day a lay teacher at the Lovedale missionary school in the rural Eastern Cape, by night he was a pioneering observer of variable stars. Late in life he came to play an important political role at the time when black Africans were beginning to claim their rights in the face of a complacent and generally-uninterested white minority government.

Alexander William Roberts came from a relatively poor Scottish family but was fortunately bright enough to receive a good education. He grew up a liberal Presbyterian and was to spend most of his life as an educator, Europeanizing and championing the rights of 'native' South Africans.

As a pioneer of serious amateur astronomy in South Africa he carved out an enviable reputation in the field of variable star studies, earning the respect of specialists in Europe and the United States of America. He eventually published nearly a hundred papers in scientific journals. This book conveys how difficult it was to do work of this kind from the isolated and