BOOK REVIEWS

Masters of the Universe: Conversations with Cosmologists of the Past, **by Helge Kragh. (Oxford: Oxford University Press, 2015), pp. [viii] + 285. ISBN 978-0-19-872289-2 (hardback), 133 × 215 mm, US$49.95.**

This rather unconventional book presents a fascinating picture of the progress of cosmology and the attitudes of cosmologists over the first two-thirds of the twentieth century. Why unconventional? It takes the form of interviews conducted by an imaginary relative of the author with fourteen scientists, mostly theoretical physicists, who did research in cosmology. Although the conversations are invented, they are accurate portrayals of what could have occurred. The scholarly notes, which, with brief biographies, comprise 40% of the book, show that in many cases the interviewee uses words he actually wrote or said.

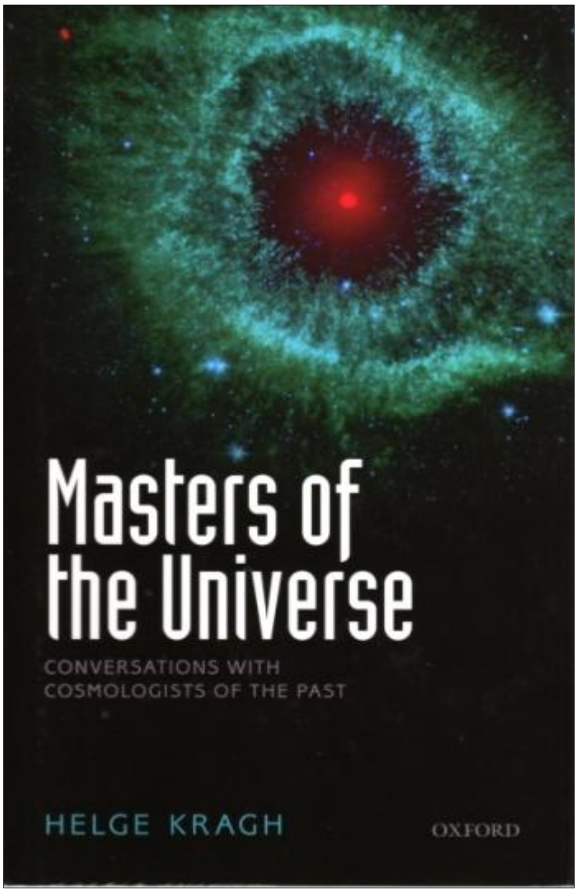
As Professor Kragh points out in the foreword, "My granduncle CCN could have existed." This man was, like Kragh, a Dane. An engineer who read and thought a lot about cosmology, he 'lived' in Denmark, Germany and the United States at different times and conducted interviews in several languages. The one great mystery in the book is the identity of the person shown in a photograph with an equally unidentified woman and labeled as the interviewer.

The first two interviewees are a bit of a surprise. Kristian Birkeland (1867–1917) was a Norwegian physicist who investigated the aurora and geomagnetism. In his 1913 interview he advocates a Universe in which interstellar space is filled with a tenuous plasma and electromagnetic forces are as important as gravitational ones.

Svante Arrhenius (1859–1927), the Nobel Prize-winning physical chemist now best-known for his prediction of global warming due to the greenhouse effect (which he thought a good thing, as it would make Sweden more comfortable), is interviewed in 1916. The Director of the Nobel Institute for Physical Chemistry considers himself a physicist now, working in many branches of science, even immunology. He advocates a Universe that is infinite in space and eternal in time, an early type of 'steady state' Universe. Light pressure plays a major role in his Universe, but the relatively new quantum ideas of Planck and Bohr are rejected as irrelevant.

Our protagonist conducts the remaining interviews with scientists familiar to those with an interest in physics and astronomy, although several are best known for their work in fields other than cosmology.

CCN's second 1916 interview is with Karl Schwarzschild (1873–1916). It is held at his Potsdam home just two months before the great astrophysicist died of an illness contracted while serving on the Russian front. Schwarzschild discusses his work on the possible curvature of space and, briefly, his papers of that year on general relativity and quantum mechanics. The chapter contains a wonderful quotation from a 1913 lecture by Schwarzschild that was published in Eddington's (1917: 319) obituary:



> Mathematics, physics, chemistry, astronomy, march in one front. Whichever lags behind is drawn after. Whichever hastens ahead helps the others. The closest solidarity exists between astronomy and the whole circle of exact science.

CCN interviews German statistical astronomer Hugo von Seeliger (1849–1924) after the Great War is over, in 1920. Seeliger has recently published the result of his life work: an investigation of the distribution of the stars in space. He has developed much of the theory of statistics of stellar distributions. He and his friendly rival, Jacobus C. Kapteyn (not interviewed), have been counting stars for decades. Seeliger's conclusion is quite similar to Kapteyn's: that the stellar system is ellipsoidal and ~10 kpc in diameter, and that the Solar System happens to be located quite near the center. Asked about the recent proposal of Harlow Shapley, that the system of globular clusters outlines a much larger galaxy centered many kiloparsecs away in the direction of Sagittarius, Seeliger states that he considers it 'plain wrong'. He says, "I suspect it's just another example of American sensationalism and tendency to megalomania." In common with Kapteyn and Shapley, he says that he has considered interstellar absorption of starlight and concluded that it is negligible. The septuagenarian Seeliger is quite conservative regarding such radical ideas as an infinite Universe or one that changes with time. He also rejects General Relativity.

The next interview, in 1928, is with Albert Einstein (1879–1955) himself. By this time CCN declares that

> … it had become clear to me, somewhat belatedly, that cosmology had entered a new phase that differed significantly from the subject as studied by classical astronomers such as Kapteyn and Seeliger. The new cosmology was essentially rooted in the general theory of relativity … (page 67).

The creator of General Relativity spends some time talking about beauty "... or perhaps sublimity is a more appropriate term ..." of the equations. He says that he has not spent much time on cosmology in recent years and that he still believes in his original model, a closed, finite, eternal Universe. He recalls informing Georges Lemaître the previous year of Alexander Friedmann's priority in finding additional, time-varying solutions to the equations of General Relativity when applied to the Universe, but stresses that he does not accept these models. This interview is timed to be just before Edwin Hubble changed cosmology forever.

The year 1933 finds CCN in Leiden, interviewing Willem de Sitter (1872–1934). By this time much has changed. Hubble's velocity-distance relation has provided evidence for an expanding Universe, and Lemaître's evolving Universe models, first published in 1927, have finally reached the influential cosmologists. The interview is far-ranging and quite interesting. It even includes a mention of Einstein's unpublished attempt at a steady state Universe with continuous creation, a model discarded by its author in 1931 and made known to the public only recently when it was discovered, translated, and published by Cormac O'Raifeartaigh and his colleagues (2014).

In 1934 CCN wisely moves from Germany to the United States. Four years later he interviews Lemaître (1894–1966) during a cosmology conference at the University of Notre Dame. The interview provides insights into the Belgian priest's views on the differences between his independent solutions to Einstein's equations and the earlier ones of Friedmann, the importance of quantum mechanics and radioactive decay to his work, and his emphatic rejection of the suggestion that his religious views affect his scientific research. There is even a mention of Lemaître's translation of his own 1927 paper into English for publication in the *Monthly Notices of the Royal Astronomical Society* in 1931, a fact only discovered after much controversy in 2011 (see Livio, 2011).

The interview with Arthur Stanley Eddington (1882–1944) was the most disappointing to me, not that it is in any way inaccurate, but because it takes place so late in Eddington's life. Had he been interviewed in the 1920s Eddington would have come across as the dominant figure in astrophysics and the most important promoter of General Relativity to scientists and the public in the English-speaking world. By 1938 he is lost in his mystical approach to the Universe, convinced that he has calculated the fine structure constant (exactly 137) and the total number of electrons in the Universe. He even spouts such nonsense as "According to my theory [the Universe] must be finite. Observations cannot give us an answer, but theory can." (page 133).

The only purely observational cosmologist interviewed is, of course, Edwin Hubble (1889–1953). The interview takes place in 1951, very near the end of Hubble's life. Hubble states that in the 1920s he kept up with developments in cosmology mostly through conversations with Caltech theoretical physicists Richard Chace Tolman and Howard Percy Robertson (who left Caltech in 1929). Hubble says

> My work of 1929 was important because it demonstrated for the first time the law of redshifts, but I did not actually conclude that the universe is expanding, and for that matter, I still feel it is premature to see in the redshift law a proof that the universe is in a state of expansion. (page 148).

and also:

> It's the privilege of the observational astronomer that he can afford the luxury of staying neutral in theoretical controversies, and it's a privilege I value. (page 149).

Our intrepid interviewer visits theoretical nuclear physicist George Gamow (1904–1968) in 1956. By this time Gamow is renowned for the theory of alpha decay, for many popular books about physics and astronomy, and especially for his strong advocacy of what Fred Hoyle has dubbed the 'Big Bang' model of the Universe. Gamow's student, Ralph Alpher, has written a famous doctoral dissertation, *On the Origins and Relative Abundance of the Ele-*

ments, in 1948, and the two, together with Robert Herman, have published several papers on the early Universe and nucleosynthesis.

In the interview Gamow refers to the early Universe as "... nature's own nuclear laboratory ..." and describes himself as a 'nuclear archaeologist' trying to reconstruct the early Universe from the current abundances of the atomic nuclei. Gamow makes it clear that his work has nothing in common with Lemaître's and that he considers only his model to be quantitative and based on nuclear reactions. He cites evidence that the Universe is infinite and hyperbolic in geometry. He is open to the possibility of a Universe that contracted before it expanded (only once) and says that we may never know. Gamow mentions the prediction of the cosmic radiation that may still be around, conveniently forgetting that he did not believe it when it was first proposed by Alpher and Herman in 1948. He takes pride in the calculations of the abundances of hydrogen, deuterium and helium, which are in reasonable agreement with observations, and concedes that it may be necessary to conclude that the heavier elements are made in stars. (Hoyle and his colleagues had just suggested this and the monumental paper by E.M. Burbidge, G.R. Burbidge, W.A. Fowler, and F. Hoyle (1957) was in preparation, although Gamow may not have been aware of it.) In common with most non-British scientists, Gamow finds it difficult to take the steady state cosmological model seriously.

The only joint interview is with Fred Hoyle (1915–2001) and Hermann Bondi (1919–2005) in 1958. There is discussion of the differences between the Bondi-Gold version and the Hoyle version of steady state cosmology. The former retains General Relativity, while the latter modifies it. The two agree on many questions, and both Hoyle and Bondi believe they have made cosmology more scientific. They disparage evolutionary cosmologies and call Lemaître and Gamow 'creationists'. Hoyle refers to the big bang as "... an irrational process outside science." Bondi is more inclined to consider philosophy and takes pride in the falsifiability of the steady state theory. They also discuss Martin Ryle's claims that radio source counts are inconsistent with a steady state Universe and Hoyle's ongoing work on nucleosynthesis in stars. The uncertainty in the ages of the oldest objects and their possible inconsistency with the Hubble time are also topics of discussion.

Historians of astronomy seldom think of Paul A.M. Dirac (1902–1984) as a cosmologist, but Kragh, who has written a major biography of Dirac, includes him among the interviewees, concentrating on Dirac's 'large number hypothesis'. In 1963 CCN travels to Cambridge to interview the founder of relativistic quantum mechanics on his cosmological research. Dirac believes that since the ratio of the electrical force to the gravitational force between a proton and an electron is of the same order of magnitude (10^{39}) as the ratio of the age of the Universe to the atomic unit of time (e^2/mc^3), that this must be a permanent law of physics, implying that the strength of the gravitational force decreases as the age of the Universe increases. He calls his assumptions "... reasonable and natural ...", although few have agreed. Dirac also says that to him 10^{-39} and 10^{-44} are of the same order of magnitude. There are definite echoes of the numerical claims made by Eddington in his last years. And the Dirac of the interview lives up to his reputation of often giving one-word answers to lengthy questions.

Our interviewer conducts his last interview at age 78 when he visits Robert Dicke (1916–1997) in 1965. Dicke is fascinated that CCN started his interviews before Dicke was born and talked with Einstein before the expansion of the Universe was known. Famous for his work on microwave radar during WWII, Dicke has achieved success in both experimental and theoretical physics at Princeton University. He heads a research group on gravity, and he and his student, Carl Brans, have developed a scalar-tensor theory that generalizes General Relativity. Dicke has explored consequences ranging from plate tectonics to a slightly different shape of the Sun.

CCN wants to know more about the microwave radiation just discovered by Arno Penzias and Robert Wilson and interpreted by Dicke, P. James E. Peebles, Peter G. Roll, and David T. Wilkinson (1965), as the cosmic background they had just 'predicted' and were preparing to search for. They seemed totally unaware that Alpher and Herman had predicted it in 1948. The Princeton physicists, or at least Dicke, considered a cyclic Universe that expanded and contracted forever, thus avoiding the creation of something out of nothing. The interview includes discussion of the history leading up to the famous back-to-back papers by the Bell Labs team (Penzias and Wilson, 1965) and the Princeton team (Dicke, et al., op. cit.) and the neglect of Alpher and Herman's earlier prediction.

I highly recommend this book. The author uses the fictitious interviews to present much factual information, revealing the personalities and attitudes of some of the principal players in twentieth century cosmology. Kragh is clearly an expert on the subject. The references include no fewer than six books and twenty-one scientific articles and book chapters by the 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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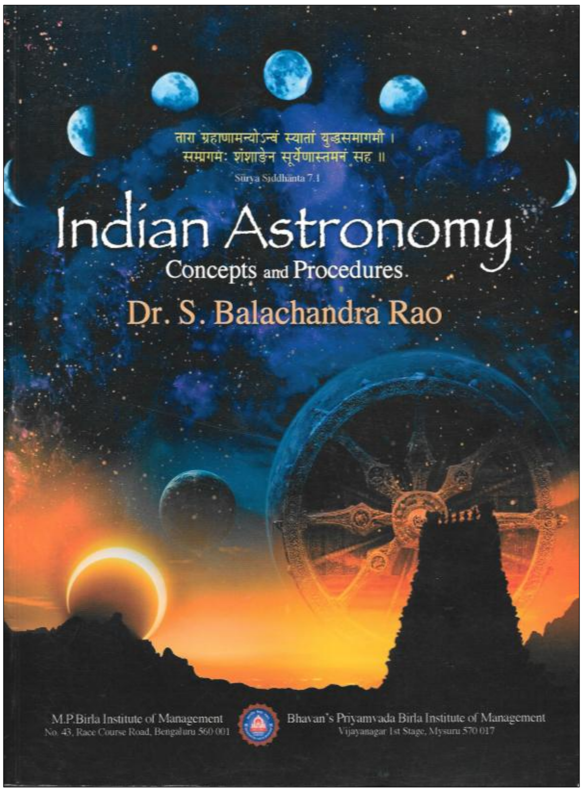
***Indian Astronomy: Concepts and Procedures*, by S. Balachandra Rao (M.P. Birla Institute of Management, and Bhavan's Gandhi Centre of Science and Human Values, Bengaluru, 2014), pp. [xiv] + 332. No ISBN (paperback), 180 × 240 mm, US$45.**

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