

Dark Matter: An Introduction. Debasish Majumdar. CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA. 2015. xi + 257 pp. Price: US\$ 89.95.

It is now common knowledge that there is matter in the universe that interacts gravitationally and gives shape to galaxies and clusters and super-clusters of galaxies, which is said to be ‘dark’, since it does not participate certainly in the electromagnetic interactions (which makes matter shine). It is likely that this matter interacts ‘weakly’ and may be participating indirectly in interactions, and when there is sufficient luminosity and when there are dedicated experiments sensitive to such rare collisions, enough events will be registered which would tell us what this dark matter is. This is the subject of the book ‘*Dark Matter: An Introduction*’ that is being reviewed here.

The book under review is a welcome addition to the library of any young researcher in the field of elementary particle physics and cosmology. Debasish Majumdar, the author of this book, is a well-known phenomenologist at the Saha Institute of Nuclear Physics, Kolkata, who obtained his training in nuclear physics at the Physical Research Laboratory, Ahmedabad. The direct approach to the subject in this book bears the hallmark of that training, and is a very physical introduction to a very tricky subject on which there is vast research literature. However, it appears that there are not many accessible textbooks on the subject and the present book admirably fills this gap. It is accessible to a beginning graduate student and is also self-contained. That said, one wonders why

such subjects are not yet part of the curriculum already at the Master’s level, where it tends to be conservative and somewhat dated. The present book convinces me that it is possible to introduce research-level topics already at that level. It is self-contained and starts at a very basic level and builds up the subject to where the reader can actually see what the research questions are. As the author has noted, in order to approach the subject at hand, it is important that the reader has a basic knowledge of elementary particle physics. The author has taken the trouble to actually introduce the subject and bring it up to the desired level in the early chapters, which is no mean effort! The basic mathematics of the subject is also explained in sufficient detail making the book of special value to non-experts. Of special note is the fact that the author provides a large number of illustrative figures with detailed explanations from a physical point of view, making the subject accessible to the non-expert.

Indeed, the research questions are on: what is dark matter, what is its nature, how does it interact, what is its signature in the cosmos, what is the evidence for its existence, and finally how is it to be detected? Its existence was inferred by the renowned astronomer Fritz Zwicky well over half a century ago, who concluded based on the behaviour of some galaxies and the application of the ‘virial theorem’, which estimates the gravitational pull of galaxies, that luminous matter could not have accounted for all the matter in galaxies. Subsequently, Vera Rubin analysed the ‘rotation curves’ of galaxies and concluded that the flattening out of the rotation curves, i.e. velocities of outlying stars in galaxies as a function of their distance from the centre could not be accounted for, unless one assumed the existence of a spherical halo even for spiral galaxies. Today there is more direct evidence from the so-called bullet cluster where two enormous galaxies collided and one can infer from gravitational lensing that the luminous matter suffered a great deal of tidal distortion, while the dark matter haloes essentially passed through each other without significant collision.

There are many theories that postulate the existence of dark matter that is now seen as essential for the very existence of galaxies, which are assumed to have formed after the big bang and because of

the clustering of matter due to inhomogeneities. In order for such inhomogeneities to have grown to the requisite scale, the presence of dark matter to sustain them is crucial. Due to the chequered thermal history of the universe, the mass of such particles is expected to be quite large compared to that of, say, the proton, of the order of several hundred times that, at least in several popular extensions of the standard model. Common extensions of elementary particle physics models which include, for example, ‘supersymmetry’ that requires particles of spin 1/2 to have spinless partners, and those of spin 1 to have spin-1/2 partners, but of significantly different masses (if the masses were the same then supersymmetry would be ‘unbroken’, which is ruled out by the non-observation of such particles), provide candidates for dark matter. If dark matter were present in the universe from a very early epoch, could it have ‘overclosed’ the universe, in contradiction to the observed expanding and even accelerating universe? It may be worth noting that it is only in the last couple of decades that the acceleration of the universe at the largest length scales has been established using supernova standard candle measurements in very far away clusters of galaxies. Such considerations limit the ‘relic density’ of dark matter, which results from detailed computations in an expanding universe scenario. Of course, none of the discussions above precludes the existence of several different kinds of dark matter existing simultaneously. Only future experiments can tell!

This book takes the reader on a delightful tour of all the ideas mentioned above. Indeed, the expanding universe is mentioned in an example of a Friedmann universe, permitted by the Einstein equations of general relativity. The book introduces us to the special theory of relativity and elementary particle physics and field theory, all of which are manifestly relativistic. It then introduces us to cosmology and the expanding universe. What is significant in this book is that it gives an ‘on-hands’ account of the numbers and scales that one encounters in this field. It presents simple derivation of complicated ideas. There is a systematic introduction to the evidence for dark matter, including in the Milky Way. The thermal characteristics of dark matter are reviewed and various popular candidates for dark matter explored.

Of special importance is the issue of dark matter detection: what are the principles of earth-based, satellite and balloon borne experiments? The author takes us on a grand tour of on-going experiments and does not shy away from discussing controversial findings of experiments. Besides, there are the two schools of detection, the so called 'direct' and 'indirect' detection methods. The author presents a detailed analysis of all these experiments. While there is no final call yet on any of the experiments, there are continuous improvements and one obtains better and better bounds on the masses and couplings of such dark matter to normal matter. The subject is a dynamic one and it is no mean feat to convey the flavour of this enterprise.

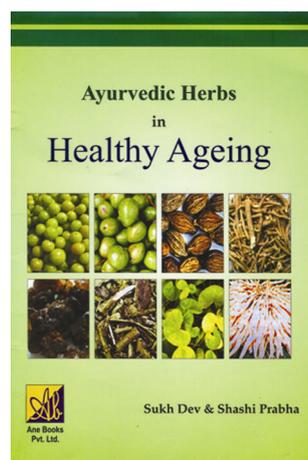
Another field of active research experimentally and otherwise is whether dark matter particles could be produced at collider experiments. Indeed, this would be the 'inverse' of particles that are already present in the universe interacting weakly with known matter, but rather that known matter could be converted into fireballs that get converted into dark matter particles, which would be highly suppressed rates due to the intrinsic weak nature of the interactions of dark matter particles. A discussion of such a topic appears to be beyond the scope of the present book. It may also be noted that the subject of dark matter detection has a future both internationally and in the country. While there is the possibility of the deep underground facility in USA, India is also contemplating dark matter search facilities. Thus the subject is an important one from many points of view.

The author, a colleague and a friend, has done an admirable job of having taken on this challenge. The book will not disappoint anyone. It is my firm belief that students who take the trouble of working through this book will find more advanced treatments of the subject to be much easier.

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B. ANANTHANARAYAN

*Centre for High Energy Physics,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: anant@cts.iisc.ernet.in*



Ayurvedic Herbs in Healthy Ageing. Sukh Dev and Shashi Prabha. Ane Books Pvt Ltd, 4821, Parwana Bhawan, 1st Floor, 24 Ansari Road, Darya Ganj, New Delhi 110 002. 2014. xiv + 138 pp. Price: Rs 295.

In the perennial quest for longevity, there are no miracle cures. As our population ages many more people are realizing that in order to stay healthy into old age we need to become proactive, improving our diets and lifestyle choices, reducing stress, and becoming more knowledgeable about our health and medicine through safe and rational use of herbs.

With this book, Sukh Dev has touched upon all aspects of ageing with practical ways for integrating this information into the daily lives of readers as to how they can live longer, better and healthier. He offers the reader safe, effective and relevant treatments for many of the ills that come with increasing age. Preventing senior moments, menopausal symptoms, prostatic enlargement and circulatory problems, and some of such answers we seek today can be found on these pages. This book offers a clear understanding of the biological processes involved in ageing, the culprits largely responsible for tipping the clock: vitamin and mineral deficiencies and diminishing hormone levels.

Herbal medicine can be as simple as brewing a pot of tea. However, knowing which herbs to use and how to use them requires experience. Through this book, Sukh Dev and his wife Shashi Prabha

have given the readers a thorough blend of their scientific knowledge and some tried-and-true remedies from their own experiences. Sukh Dev is an acclaimed scientist, but formulations generated from eight plants, namely Amlalaki, Bibhitaka, Haritaki, Ashwagandha, Guduchi, Guggulu, Mandookparni and Shatavari as a part of the culinary diet by his wife and tested over decades on themselves speak volumes about their ingenuity and practical experience in this science of Ayurveda. The book is an essential resource for anyone who wants to learn how their bodies work, how they age and what they can do about it. Readers will learn how to naturally maintain their vitality with ripening age, strengthen their immune system, nourish their body, burn fat and build lean muscle, and maintain a youthful mind and spirit. The authors provide herbal treatments to restore and protect each of the body's major systems – from the muscles, bones and digestive system to the pulmonary, cardiovascular and reproductive organs – as well as herbal remedies for specific ailments such as prostate enlargement, hot flashes, hypertension, insomnia, bronchitis, varicose veins and arthritis.

The book also offers preparation methods and recommended dosages. This authoritative guide to herbal preventive medicine offers holistic treatments designed not only to promote vibrant health, but also to provide a way to age with grace. One can grow old, but stay healthy both physically and mentally like Sukh Dev (in his early nineties) and Shashi Prabha (in her eighties) by following their way of life.

Ayurvedic Herbs in Healthy Ageing is an invaluable resource written in simple and easy style and must be read by all interested in maintaining their health with growing age.

K. K. BHUTANI

*National Institute of Pharmaceutical
Education and Research,
Sector 67,
S.A.S. Nagar 160 062, India
e-mail: director@niper.ac.in*