

Annual Review of Astronomy and Astrophysics, 2021. Ewine F. van Dishoeck and Robert Kennicutt (eds). Annual Reviews, 4139 El Camino Way, PO Box 10139, Palo Alto, California 94304-0139, USA. Vol. 59. x + 488 pages. Price: US\$ 118.00.

It is not an easy task to review the *Annual Review of Astronomy and Astrophysics (ARAA)* series. Each volume contains a dozen or so articles written on various topics by experts in the field, which provide excellent exposition on them. The 11 articles in this volume edited by the distinguished astronomers van Dishoeck and Kennicutt, provide for a compelling reading and help us learn something about the subject, while providing a good review of it.

The first autobiographical article in the volume is by Govind Swarup, who established the Ooty radio telescope and the Giant Metrewave Radio Telescope. It is beautifully written and describes in a humble manner how Swarup established world-class radio astronomy in India. He unfortunately did not live to see the article in print. The other 10 articles cover a large range of astronomical topics from the Sun to the cosmos.

‘Carrington Events’ by Hugh S. Hudson describes giant flares on the Sun and other stars. These are named after a superflare which occurred in 1859 on the Sun. In their extreme form, these superflares can cause difficulties to life on Earth and other Earth-like planets due to the flaring in their own stars. The original Carrington flare, the new data from precise stellar time-series photometry for the Sun and stars, and geophysical data are described in the article, followed by the current theoretical understanding. Another article on the solar system objects ‘Transneptunian Space’ by Gladman and Volk discusses small objects found in the Kuiper Belt, covering mainly planetesimal and planet formation and the relationship with protoplanetary disks.

Moving further out, the article ‘Microarcsecond Astrometry: Science Highlights from Gaia’ by Brown covers the precision astrometry achieved in the Gaia DR2 data release and the impact that the data has made on the study of our Milky Way galaxy. Going beyond that, the data have enabled studies ranging from the shapes and atmospheres of the Kuiper Belt objects using stellar occultations, to subtle features in the observation of the Hertzsprung–Russell diagram, detailed mapping of globular cluster and satellite galaxy orbits, discovery

of new gravitationally lensed quasar systems, and so forth. Covering the ever-expanding zoo of exoplanets, the article ‘Exoplanet Statistics and Theoretical Implications’ by Zhu and Dong covers the distribution and statistics of the properties of exoplanet populations and the exoplanetary systems in the inner 1AU region, which has been well studied by the *Kepler* mission. The authors also discuss the theoretical implications of the observational results for planet formation and dynamic evolution.

Two articles on stars are ‘Evolution and Mass Loss of Cool and Aging Stars: A Daedalean Story’ by Decin, and ‘New Insights into Classical Novae’ by Chomiuk *et al.* respectively. Decin discusses how the widely used interpretive framework of 1D models leads to mass loss rates differing by orders of magnitude, and how the 3D complexities harboured by stellar winds need to be addressed for proper quantification of stellar mass loss and its effect on stellar evolution. In the other article, Chomiuk *et al.* survey the current understanding of classical novae, which are eruptions on the surfaces of white dwarfs, triggered by accretion of matter from a non-degenerate companion star in a binary. The implications of the recent discovery of GeV gamma-rays from galactic novae are discussed.

In the article ‘First Multimessenger Observations of a Neutron Star Merger’, Margutti and Chornock describe the observations of the merger of the neutron star binary GW-170817, which was first detected by the Advanced LIGO and Advanced Virgo gravitational wave interferometers. The detection of the merger was followed by electromagnetic observations from gamma-ray to radio wavelengths. All these observations, the inferences drawn from them, and the open questions and future prospects are discussed.

The volume has one article on cosmology, ‘Wave Dark Matter’ by Hui. The bosonic dark matter candidates considered here are lighter than ~ 30 eV, with de Broglie wavelength larger than the average interparticle distance in a galaxy. The motivations from particle physics for considering such particles and the phenomenology associated with them are also described in the article.

The remaining two articles, ‘Observational Constraints on Black Hole Spin’ by Reynolds and ‘Tidal Disruption Events’ by Gezari respectively, deal with massive black holes. According to the no hair theorem of black hole physics, a black-hole can at the most have three observable parameters, viz. mass, spin (angular momentum)

and electric charge. The last is mainly a theoretical possibility, since black holes are formed from electrically neutral matter. Black-hole mass is measured or estimated from the dynamics of the stars and gas surrounding a black-hole, and through other more indirect means. The article by Reynolds describes the techniques currently used to detect and measure the spin of black holes. After a brief, but useful introduction to the physics of black holes and black-hole accretion physics, Reynolds describes various techniques used to measure the black-hole spin. These include the two main techniques, viz. X-ray reflection spectroscopy, where the shape of the 6.4 keV iron- $K\alpha$ emission line is used estimate the spin, and thermal continuum fitting. The other techniques describe spin estimations using quasi-periodic oscillations, radiative efficiency, jet power, quasar microlensing and the recent use of direct imaging of horizon-scale emission from black holes in the radio galaxy M87 and in our galaxy. While these are all electromagnetic techniques, the observation of gravitational waves from spiralling-in and merging compact objects provides a completely different method for spin measurement. Reynolds provides a summary of spin measurements from merging compact objects detected by the three LIGO–Virgo observing runs. After description of the measurement techniques, he summarizes all the spin measurements available to date, the astrophysical implications and outlook for the future.

I first read about tidal disruption events (TDEs) in an insightful paper by Martin Rees (*Nature*, 1988, **333**, 523), when it first appeared. When the orbit of a star takes it close to a massive black hole at the centre of its galaxy, the star can be violently disrupted or get swallowed as a whole by the



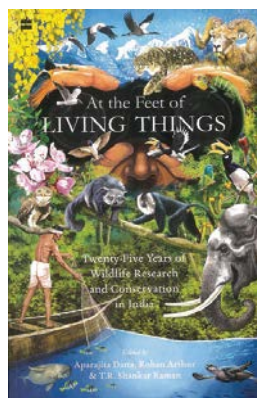
One of the 30 Giant Metrewave Radio Telescope antennas of 45-m diameter: 10 other antennas can be seen in the distance.

black-hole, depending on the relative value of tidal disruption radius and the event horizon radius. If the mass of the black-hole is $<10^8 M_{\text{Sun}}$, the tidal radius is larger than the event horizon radius and the star is disrupted. For more massive black holes, the star is captured as a whole by the black hole. In the case of disruption, the bound fraction of the debris falls into the black-hole, emitting a luminous flare of radiation and forms an accretion disc around the black-hole. The timescale for this is in months, so that formation of the accretion disc and a jet can be observed in real time. In her article on TDEs, Gezari first describes the observed properties of the 56 TDE candidates which have been discovered to date in the optical, ultraviolet, X-ray or gamma-ray bands. She then discusses the tensions between observations and theory of TDEs, and how the observations have outpaced theory, so that there is no basic understanding yet of a physically motivated model for the disruption debris and formation of the disc. Understanding TDEs is important as the rates at which stars are disrupted depends on black-hole properties like their mass and spin, the nuclear stellar density and its orbital distribution, presence of a binary black-hole, and so forth. The TDEs can therefore act as a probe for massive black-hole demographics. Gezari ends with a discussion of improving search strategies, detection of intermediate mass black holes through the tidal disruption of white dwarfs and TDEs as multimessenger sources.

The articles in the volume are all highly readable. They provide a concise state-of-the-art summary useful for the expert as well as for readers new to the field. The production quality of the volume is high, and reading from it is a pleasant experience than reading a preprint of the article on a screen. I highly recommend this volume.

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At the Feet of Living Things: Twenty-five Years of Wildlife Research and Conservation in India. Aparajita Datta, Rohan Arthur and T. R. Shankar Raman (eds). HarperCollins Publishers India, 4th Floor, Tower A, Building No. 10, Phase II, DLF Cyber City, Gurugram 122 002, Haryana. 2022. xxx + 378 pages. Price: Rs 599. ISBN 978-93-9440-785-5.

During the past 50 years, India has shown determination in combating the loss of species and their habitats. The approach has been one of setting aside protected areas throughout the country. This initiative backed by legislation has proved to be robust. A network of more than 800 protected areas covering a meagre 5% of the country's geographical area has resulted in endangered species like the tiger, elephant, rhinoceros, lion and several other lesser-known species of wild animals showing heart-warming recovery. While wildlife enthusiasts have hailed the success and demanded that more habitats should be brought under the system of legally protected areas, human rights activists and organizations have criticized the move as one that is indifferent to the livelihood of the local communities. They contend that human communities which live in and around the protected areas have been deprived of their fundamental rights to land and the access to natural resources. In addition, increase in the population size of many animals has led to spillovers and frequent conflicts with humans who live in and around the protected areas. Such conflicts have resulted in the loss of crops, livestock and the lives of both humans and animals.

Starting with the Man and Biosphere Programme, several strategies have been adopted to minimize and mitigate human-wildlife conflicts and make wildlife conservation more inclusive. Besides establishing 18 biosphere reserves, the Government of India has also launched people-centric pro-

grammes such as the joint forest management programme and eco-development projects around protected areas throughout the country. Newer forms of less stringently protected conservation areas such as community reserves and conservation reserves have also been established. However, these interventions have had only limited success in earning the goodwill and unconditional participation of the local communities. Several conflicting issues have not been fully addressed.

The diversity of endemic human cultures in India, their dependence on natural resources, beliefs and attitudes towards wildlife have together underlined the need to evolve locality-specific and inclusive wildlife conservation strategies. This is a task that no government can handle exclusively. Governments have to work closely with non-government entities so that the conservation goals are fully achieved. It is against this backdrop that the book under review becomes relevant.

It is a collection of 16 essays by more than 20 authors, who are researchers linked to the Nature Conservation Foundation in one way or another. The essays distributed under five thematic sections have been written in a 'storytelling' style, summarizing the authors' experiences while trying to understand and deal with diverse conservation challenges throughout the country. The essays take the reader from Lakshadweep Islands to the Andaman and Nicobar Islands. And then from the Western Ghats to the rainforests of the Eastern Himalaya and the cold plateaus of the Western Himalaya. The authors have been honest in presenting both successes and failures. There are nice black and white illustrations throughout the book.

Coral bleaching in the Lakshadweep Islands, overfishing in the reef and depletion of seagrass beds by green turtles pose contrasting challenges to researchers concerned with the conservation of the Island's fragile ecosystem. Proposals for the socio-economic development of the Island seem like an unsurmountable threat. On the other side, the survival of the dugong in the Andaman and Nicobar Islands hangs precariously under the pressures of tourism and infrastructure development. The future of this marine mammal lies entirely on the patterns of succession in seagrass beds of the Island.

Elsewhere in the Western Ghats, restoration of forest fragments in the Anamalais has given positive results. However, the support of the private sector that manages coffee and tea cultivation in the landscape