

Solar power, fusion, and snapping shrimp

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It is now 200 years since Governor Thomas Brisbane first convened a meeting of the Philosophical Society of Australasia in Sydney. After a COVID-related delay, the Society marked its birthday with an exhibition — NEXUS — about the history and achievements of the Society, at the State Library. Three events followed: a Garden Party hosted by the Governor at Government House on 12 March 2022; a Gala Dinner in the Great Hall of the University of Sydney, addressed by the Governor General, former patron, the former Chief Scientist of Australia, Alan Finkel, on 24 June; and a Reception at Admiralty House hosted by the Governor General on 7 November. Their addresses are printed below, as well as greetings from people and organisations around the world, a description of the NEXUS exhibition, and the programme for the Dinner.

In October, Martin Green won the Millennium Technology Prize, Finland's top technology award and often a precursor for a Nobel Prize. Professor Green was awarded the prize, worth €1 million (\$1.54 million), for his work in developing the Passivated Emitter and Rear Cell (PERC), a solar cell that's proved to be so efficient, cheap and scalable that it's already changed the world by its mass deployment. His laboratory at UNSW continues to lead the world in further improvements to the cell. Many of his former PhD students now hold key leader-

ship positions at five of the world's six major solar cell producers. I asked Professor Green, a former FRSN, whether we could publish his acceptance speech from the ceremony in Helsinki, and he agreed. Read the history of the PERC cell's development.

As the winner of the Society's 2021 History and Philosophy of Science Medal, Dean Rickles submitted a paper, "*Quis custodiet ipsos custodes?*"¹ From quantum gravity to second-order cybernetics," which discusses the role of subjectivity in understanding reality in fundamental physics. The paper is accompanied by a famous sketch by Max Escher of two hands drawing each other, which, Rickles believes, captures the role of the observer in quantum gravity, and consciousness. See what you think.

There follow two papers on science-related government policy. Peter Shergold FRSN has written a summary of the findings of a committee he chaired on Australian governments' responses to the COVID pandemic. With no government funding, and no government representatives, this report is truly independent. One important recommendation is that Australia establish a national Centre for Disease Control. Apparently we are the only OECD nation to lack such a centralised organisation, and readers might remember an earlier call for such a body in Eddie Holmes' paper (2019). Shergold's summary ends with the admo-

1 My understanding of this is: Who will guard the guardians themselves (*ipsos*)? [Ed.]

dition that we must learn from our recent experience so that we are better able to deal with the next pandemic, “which will come.”

As a consequence of the AUKUS agreement among Australia, the UK, and the USA, for Australian nuclear-powered submarines, Brian Schmidt DistFRSN reflects on Australia’s growing need for STEM graduates to service the machines. He argues that we should view the subsequent demand for qualified graduates as an opportunity to alter our universities’ approach to STEM-focussed students, as Australia builds a support industry from scratch for submarine maintenance.

Andrew Blakers FRSN and colleagues have recently published an Atlas of Bluefield Sites for pumped hydro energy storage (PHES). PHES is a means of augmenting renewable energy by storing it as the potential energy in water pumped from a lower to a higher reservoir, for release to the lower dam via electricity-generating turbines. Only one new reservoir is required per Bluefield site. For the Bluefield Atlas, Blakers and his associates searched near every existing reservoir in Australia to find a potential matching reservoir site to form a PHES pair. This follows Blakers (2020), a contribution to the Point Counterpoint debate about energy. PHES facilities are needed to make firmed renewable energy available when solar and wind power are not sufficient. Unlike Snowy 2.0, the small-scale sites identified in the Atlas could be built with low costs and much lower environmental impacts.

A final paper is a departure. Some Australian readers might remember a book first published in 1952, *Australian Seashores*,

by Dakin, Bennett, and Pope, reprinted and revised until 1987. Seventy years ago it was noteworthy in having two female authors, Isobel Bennett of the University of Sydney and Elizabeth Carrington Pope of the Australian Museum. An exhibition at the University of Sydney’s Chau Chak Wing Museum (2022–2023) celebrates the landmark volume. The exhibition’s curators, Anthony Gill and Kelsey McMorrow, at my request, have written a paper describing the book, the exhibition, the three authors, and the collection. The book mentions the mystery of the snapping shrimp, *Alpheus strenuous*, which has evolved a way to, presumably, scare off predators with a deafening “snap!” How does it produce this sound? We now know that it occurs through cavitating bubbles. The book pioneered the idea of “citizen science” in Australia.

Since 2016, we have published 107 abstracts from dissertations of PhD graduates from NSW and the A.C.T. An abstract this issue caught my eye: Dr Lara Cullinane, who graduated from ANU and is now at Johns Hopkins in the U.S.A., studied the structure and movements of the interactions between the Large and Small Magellanic Clouds which are clearly visible in the southern sky. But not, ironically, from Maryland.

Wildlife in the suburbs

The Australian Brush Turkey (*Alectura lathami*) is commonly found north of Sydney, where they have established themselves in suburban gardens, as well as the brush (i.e. rainforest), where their common name suggests they are more at home.² Recently, however, they have crossed the Harbour. Last year I saw my first Brush Turkey in

² Also known as the Scrub Turkey, where “scrub” is another settler word for rainforest.

Balmain. They built a mound or nest in the Terman Street Reserve, where at least four chicks hatched and survived. Later, I learnt that another mound was built in the gardens of Ewenton House. This year, the Terman Street Reserve mound has been renewed, and a new mound also built on land at the end of Blake Street, where one chick or poult (sadly since dead) has hatched.

How did the Brush Turkeys cross the Harbour? They can fly, at least enough to flee cats and to chase each other through the trees of the Reserve, so did they fly across? Walking is unlikely, although there is one report of a Brush Turkey on the Harbour Bridge. Will they continue south? It would be a bold prediction to say that they will never be found in Sydney's western suburbs. The rainforest of the Illawarra awaits.³

Fusion power?

Recent breathless reports tell of successful fusion at the National Ignition Facility in California. They tell of a net energy output with a fusion reaction of deuterium and tritium, two isotopes of hydrogen. Compressed together sufficiently tightly by laser, their nuclei fuse to create a helium nucleus, a neutron and some energy. The compression must overcome the mutual repulsion of the positively charged nuclei and push them sufficiently close for the short-range strong nuclear force to take over. This force attracts the nuclei together into the new helium nucleus, which needs less energy to bind it than do the parents. The surplus energy is released. Such an outcome — Net Energy

Gain — had never been achieved before. But the net positive energy is solely accounting for the energy focussed on the two isotopes, not the very much larger amounts of energy needed to prep the aging lasers. And the amount of energy produced by the fusion was small, and was only for a few nano seconds. To scale this process up will require tremendous engineering developments. Yes, fusion is carbon-free, but so too is fission. And wind and solar renewables are not only radiation- and carbon-free, but they are technically and economically feasible now. Nonetheless, noted theoretical physicist Heinrich Hora FRSN is associated with an Australian start-up, HBII Energy, that is focussed on fusion (Lu 2022).

The first functioning laser (Light Amplification by Stimulated Emission of Radiation) was constructed in 1960. For the next twenty years, Heinrich Hora researched the applications of lasers for producing nuclear fusion energy. Hydrogen–boron II fusion has always been the ultimate fusion reaction. It does not create radioactive waste (no neutrons produced,⁴ only three helium nuclei and kinetic energy) and its fuels, hydrogen H — not deuterium or tritium — and boron II, are both abundant in nature (unlike deuterium and tritium) and non-radioactive. Few other researchers had studied this reaction, as it was considered too difficult to achieve. The temperatures required to ignite the reaction are more than 100 times higher than that of the sun — a technical hurdle that has held back practical energy generation for decades.⁵

³ A recent book is (Hunter 2018). See also Bolger & McCullagh (2022).

⁴ No neutrons are produced when the reacting H-nuclei (protons) have energy lower than about 3 MeV (Hora et al. 2017).

⁵ I have borrowed from the HBII Energy web site for this description, <https://hbii.energy/our-story/>

In 1978, Professor Hora explored an alternate means of achieving the fusion reaction without high temperatures. But his approach suggested using lasers that did not yet exist. This changed dramatically after Donna Strickland and Gerard Mourou demonstrated Chirped Pulse Amplification (CPA) of lasers in 1985. Their experiment set a direction for high-power laser technology development. In recent years, scientists have reached the requirements first predicted by Prof. Hora to achieve the HB_{II} reaction.⁶ Their work on CPA lasers won Strickland and Mourou the 2018 Nobel Prize in Physics.

The HB_{II} fusion process is radically different from the previous focus of generating fusion via thermal equilibrium — i.e. heating the fuels to tens of millions of degrees C to achieve ignition. In contrast, by using CPA lasers or their successors, the HB_{II} concept offers an alternative that does not require heating fuels to extreme temperatures. As their concept converts nuclear power directly into electricity, HB_{II} Energy will not need the steam turbines and generators required for coal or conventional nuclear-fission power plants, so their plants can be much smaller and there is no risk of reactor meltdown.⁷ HB_{II} Energy plans to use hydrogen and boron 11 nuclei as the fuel in its process, as this fusion reaction produces much less radiation than the deuterium-tritium reaction. Read Hora et al. (2017) and Daponta et al. (2022) for the details. But don't hold your breath: this too is far from ready.

DOIs and the Royal Society

Readers who have used the Contents (or Archive) web page of the *Journal & Proceedings* will perhaps be aware that the Biodiversity Heritage Library (BHL), a branch of the Smithsonian Institution in Washington D.C., have scanned back issues of the *J&P* since 1867 and earlier, and have placed these scans on-line in their repository, to which a click will direct the researcher from our Contents page. We had lost contact with the BHL until, as a result of Councillor Davina Jackson's efforts to build a single index of author and title for all papers since 1821, I re-established contact with the BHL (our last direct contact had been in 2014). We found that the BHL has undertaken to provide DOIs (Digital Object Identifiers) for all papers in their repository, including all 2,000-odd of the Society's published papers back to 1867 and earlier. We quickly signed up.

For a year or so we had been considering obtaining DOIs for our recent papers, but had been daunted by the logistics and cost. We therefore jumped at their offer. Some years ago we had obtained an ISSN for the on-line version of the *Journal*, a requirement for allocation of DOIs. After I took over as editor in 2016, I spent six weeks indexing the BHL repository of Royal Society papers — author, title, journal, pagination, issue and volume, dates and, significantly, each paper's URL in the BHL repository. These are the metadata associated with each paper, absolutely necessary for the DOIs. And for the Contents Archive pages on the Society's web site.

⁶ The petawatt laser used was in Japan; Australia does not have such a facility. <https://www.afri.com/technology/bold-plan-to-generate-limitless-power-with-giant-lasers-20220216-p59x29>

⁷ See Subramanian (2022) for a description of the problems and costs of decommissioning a nuclear fission reactor, with its attendant radioactivity.

They have begun. The BHL has already provided us with the DOIs for the Society's earliest publications, the *Transactions of the Philosophical Society of New South Wales, 1862–1865*, and the *Transactions of the Royal Society of New South Wales, 1867–1874*. They are continuing with the *Journal & Proceedings 1875–*. (Although the Contents/Archive pages point to presentations made at earlier Society meetings, these were not published, if at all, in Society publications, and so will not be allocated DOIs by the BHL; the content is still available online, usually at the National Library of Australia's Trove database.) These earliest DOIs have been added to the Contents/Archive pages, as will the DOIs to later papers. The DOI points to the metadata for each paper, and from there is a link to the paper on the BHL repository.

What is so special about DOIs, I hear you ask? The DOI system provides a technical and social infrastructure for the registration and use of unique persistent identifiers, DOIs, for use on digital systems. The unique string of numbers, letters, and symbols is used to identify an article or document (journal articles, research reports, data sets, and official publications). Each DOI is resolved to its target, the object to which the DOI refers, achieved by binding each DOI to metadata about the object, including its URL, where the object is located on the web. Thus, by being actionable (and interoperable) a DOI differs from an ISBN or ISSN, which is an identifier only. Each DOI remains fixed over the lifetime of its document, whereas the metadata may change. If

so, the publisher must update the metadata associated with the DOI, such as its URL.

DOIs were introduced in 2000, coincidentally the year in which the Society started systematically making the pages of the *Journal* freely available online. Since then, approximately 275 million unique DOIs have been assigned. With DOIs for all the papers in our publications, the Society and its *Journal & Proceedings* fully joins the world of digital publications.

Recently we have received news of the deaths of two Fellows: Ragbir Bhathal FRSN, a past president and librarian of the Society, died on 30 November 2022, aged 86.⁸ Chris Fell AO FRSN died on 8 December 2022, aged 82. We shall print obituaries of the two men in 2023.

Housekeeping

Donald Hector, past president of the Society, past editor of the *Journal*, and stalwart member of the *Journal's* editorial board, has stepped up to help me with my editorial duties. He recently suggested that we put out a call for longer, reflective, essay-style papers that we could consider publishing in a separate issue. A good suggestion, and we hereby invite such submissions.

As usual I thank Jason Antony MRSN for his excellent text processing, and Rory McGuire MRSN and Michael Burton for their proof-reading; Len Fisher FRSN gave me valuable advice on physics. As an aside, I ran an earlier version of this editorial through the new AI wonder, ChatGPT;⁹ it suggested readability changes, some of which I have adopted here. My judgement? It's nothing spectacular as a copy editor.

⁸ As one of a series of interviews he conducted with prominent Australian scientists, Professor Bhathal organised an interview with Ron Bracewell AO that was published in the *Journal* as Bracewell and Bhathal (2018).

⁹ See <https://openai.com/blog/chatgpt/>

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