international radio astronomy project now known as the Square Kilometre Array. The SKA collaboration chose sites in South Africa and Australia, and a design using smaller, cheaper dishes, but China's government stepped up in 2007 to build FAST anyway.

Construction on the facility was completed in 2016 and it is still in the commissioning phase. But, it has already found 44 pulsars — neutron stars formed in a supernova explosion with powerful magnetic fields that appear as pulses of radio waves as they spin. FAST could double the known pulsar tally of 2,000, says Peng. It's also ideal for mapping gas clouds between stars and for listening for signals from any alien civilizations.

MIND THE GAP

The next challenge is to wrap up FAST's commissioning and begin operations in earnest — hopefully by 2019. FAST's unique dish is made of 4,450 panels, some of which can be angled by actuators — winches dug into the mountain sides to adjust the telescope's focus. By reshaping its surface, it can be more sensitive to signals from a wider range of direction, off its main axis. But maintaining precise control of them has proven difficult.

"Astronomy is easy; actuators are hard," says Li, who also served as FAST's deputy chief engineer. "And money is harder."

A quirk of China's regulations means FAST is in a funding lull: its construction funds are exhausted, but until it passes its final review from the National Development and Reform Commission, it's not eligible for operational grants and is relying on stopgap funding from the NOAC and its parent organization, the Chinese Academy of Sciences (CAS). This means that the project has not yet received any funds to prepare for the immense amounts of data the telescope will collect. The team has been working to get preliminary results, but the bulk of the data-processing pipeline, which will be crucial to outside users, is yet to be developed.

FAST's leaders remain confident it will pass its project review within a year, at which point the telescope will be deemed a fully fledged national observatory. The design specifications have been met in major areas, such as sensitivity and tracking, says Li. And if it passes, some outside users will be able to access the telescope as soon as late 2019 — if they are willing to shoulder some of the burden of processing the data.

OPEN SKIES

The number of international astronomers that will be among those outside users is yet to be determined. FAST's top scientists intend for it to be as open as possible. "We will strive for an open sky policy because that has been the convention, particularly for radio astronomy, if not all astronomy," says Li. However, the decision lies with NOAC and CAS.

Peng says some have suggested reserving 60–70% of FAST's observing time for Chinese researchers and 20% for foreigners, with 10–20% allocated at the director's discretion.

Li says that the US National Science Foundation has approached Chinese agencies in an attempt to secure access for US scientists. He adds: "We have benefitted from access to US astronomical facilities," as well as data from NASA space telescopes. "The trend is to become more open and that will also help the productivity of the facility."

Peng foresees a challenge in opening the facility to international observers: translating FAST's voluminous documentation for operating and data processing from Chinese to English.

When it does open to other users, there will be no shortage of eager applicants. "It's going to be a great instrument," says Jason Hessels, an astronomer at the Netherlands Institute for Radio Astronomy in Amsterdam. He hopes to point FAST towards recent supernova explosions to search for the faint emission from potential neutron stars. The search could yield a new class of objects — neutron stars emitting bursts of radio waves due not to their rotation, but from the decay of their magnetic fields. "We've never studied such newly born neutron stars before, so there are bound to be surprises." ■

ASTRONOMICAL AND SPACE SCIENCES

TOP INSTITUTIONS 2015–2017:
1. Peking University (Fractional count: 9.12)
2. Fudan University (FC: 8.17)
3. Beijing Normal University (FC:7.80)

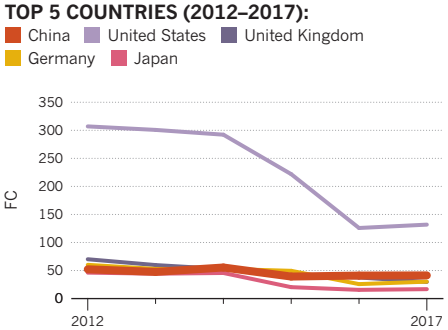
CHINESE INSTITUTIONS IN SUBJECT'S GLOBAL TOP 20: 1

INTERNATIONALLY COLLABORATIVE ARTICLES 2015–2017: 58.5%

TOP CHINESE–INTERNATIONAL COLLABORATIVE PAIR 2015–2017:
Fudan University – University of Tübingen, Germany (CS*: 4.92, Article count: 6)

ATTAINS WORLD NUMBER ONE: NA

TOP 5 COUNTRIES (2012–2017):



*Bilateral collaboration score

SMALL SCIENCE GROWS LARGE IN NEW HANDS

China's nanotech industry is forging ahead, with high funding levels, a maturing talent pool, and international experience.

BY SARAH O'MEARA

Three years ago, chemist David Leigh was ambushed by a smiling master's student from Fudan University waving a CV and looking for a PhD position at Leigh's lab in the United Kingdom.

Leigh, who leads a world-renowned lab at the University of Manchester, had just given a talk on molecular structures in Shanghai. But he was not familiar with Fudan. "I know now it's one of the top universities in China, but I'll admit I didn't then," he says.

The chemist, a fellow of the Royal Society, has become used to the huge enthusiasm exhibited by early-career Chinese scientists who attend his lectures in China. "There'll be crowds at 8.30 a.m. and students gather afterwards for autographs." The CV-brandishing Zhang Liang stood out. Keen to study overseas, he knew winning one of the 10 places available each year at Leigh's prestigious lab was a long shot, so he pushed himself forward.

Happily, it worked out. Leigh, who recently made the world's first molecular robot constructed of atoms, hired Zhang. Two years later, the young Chinese scientist was working on his organic chemistry PhD in Manchester, while managing the creation of Leigh's first nanotech lab in China at East China Normal University (ECNU) in Shanghai.

Over the past 20 years, China has become an influential force in nanoscience research, with particularly high publication rates in catalysis and nanomedicine. Yet despite the productivity and substantial funding, ground-breaking research with broad applications delivering substantial returns on investment has not followed. To deliver such results, researchers say the government needs to invest more in closing the gap between basic research and the industrialization of nanotechnologies. Compared with other big research countries, the percentage of papers with industry co-authors in China remains relatively low.

CATALYSING SCIENCE

China's rise in nanoscience is due to the country's high levels of investment in the field and ambitious targets for research and development overall, such as making the country a

SOURCE: NATURE INDEX/DIMENSIONS FROM DIGITAL SCIENCE

SOURCE: NATURE INDEX/DIMENSIONS FROM DIGITAL SCIENCE

world-leading scientific powerhouse by 2050.

In 1990, the government began investing in nanoscience via schemes such as the State Science and Technology Commission's Climbing Up project on nanomaterials. In 1999, the Ministry of Science and Technology began a basic research project, Nanomaterial and Nanostructure, and by 2006 the field had become one of the four pillars of basic research that received targeted funding from central government. Last year, the Suzhou Institute of Nano-Tech and Nano-Bionics announced a US$200-million plan to build the world's largest multifunctional nanoscience research facility for computer and robot technologies.

China's nano-related output has grown from 820 papers in 1997 to more than 52,000 papers in 2016 in the Science Citation Index. Four of the top 10 institutions for high-quality nanotechnology output are in China, according to the index.

The most popular area of the country's nanoscience papers is in catalysis research, according to the number of articles listed in *Nature*'s Nano database, a web platform that examines the quantity and impact of nano-related research papers published globally. Experts predict this area of nanoscience research will continue to flourish. A team of scientists led by Bao Xinhe at the Dalian Institute of Chemical Physics has developed a catalyst that enables the direct conversion of synthetic fuel gas to light olefins, the basic building blocks of plastics.

NANOTECHNOLOGY

TOP INSTITUTIONS 2015–2017:
1. Tsinghua University (Fractional count: 29.16)
2. Peking University (FC: 28.45)
3. Soochow University (FC: 24.23)

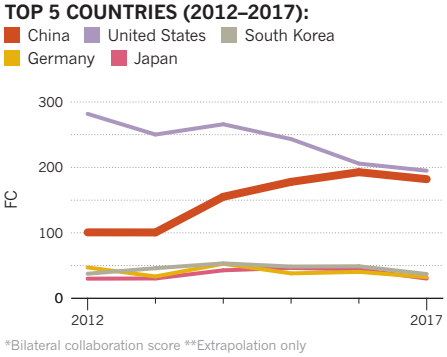
CHINESE INSTITUTIONS IN SUBJECT'S GLOBAL TOP 20: 7

INTERNATIONALLY COLLABORATIVE ARTICLES 2015–2017: 49.9%

TOP CHINESE–INTERNATIONAL COLLABORATIVE PAIR 2015–2017:
Soochow University – Monash University, Australia (CS*: 3.92, Article count: 6)

ATTAINS WORLD NUMBER ONE: 2018**

TOP 5 COUNTRIES (2012–2017):



*Bilateral collaboration score **Extrapolation only

MODEST RETURNS

Chinese researchers have also contributed to nanomedicine applications, such as improved methods for treating cancer. Despite such developments, Dai Qing, who returned to China in 2012 to launch a nanophotonics laboratory at the National Center for Nanoscience and Technology, is among those who believe Chinese scientists should push for stronger returns on investment. "We need to find a stand-out application to demonstrate that it is beneficial to the country to spend this money, not just talk about the possibilities," he says.

Dai says that the grants structure has changed to reflect a push for tangible outcomes. "If you want a flagship grant you definitely need to find an industry partner." Examples of change include developing interdisciplinary teams within Chinese institutes, taking a stronger lead in international projects, and working more closely with industry partners. For example, in May 2018, a minimally invasive cancer therapy was trialled in Shanghai. The 'nano gun' is a device loaded with anti-cancer agents that is injected into tumours. It was developed by a Chinese team working with Algerian researchers, based in France. If trials are successful, it will be developed for application in China.

As a young scientist Zhang, whose drive impressed Leigh, broke with tradition by initiating a conversation with his former professor, Hai-Bo Yang, from ECNU's Department of Chemistry about starting a lab, which is now open. "Historically, respected Chinese academics court international talent to create collaborations. I realized young starters could do it with the help of senior local professors," Zhang says. "To succeed in academia you need to learn to make connections."

In 2018, China established its first private research institute, Westlake University in Hangzhou. It is backed by some of the country's wealthiest industrialists, including Ma Huateng (Pony), founder and CEO of Internet giant Tencent, and Wang Jianlin, founder and chairman of the Dalian Wanda Group.

Many agree that while China has a bright future, cultural factors can hinder its ability to compete. On Zhang's new team are four postdocs, two from China, and two from the UK and Germany. All were invited to Manchester for training. During that period Zhang noticed how culture and language influence research styles. "Discoveries often come from conflict or argument. But Chinese people can be culturally averse to this," he says. "Also, when you're working in your second language, it can be hard to argue your point."

Zhang believes the country will become a nanotech world leader. Certainly, Leigh believes that his days of being revered in China are numbered. ■

ENGINEERING A BIOMEDICAL REVOLUTION

A permissive regulatory climate and a pragmatic approach has seen China's bioscience sector soar.

BY SMRITI MALLAPATY

For the past 20 years, French neuroscientist Erwan Bezard has spent at least one week every two months in Beijing. Bezard makes the long journey from France to visit the primates bred in Chinese labs.

China has become the top destination for research involving these animals, which are invaluable models for studying human disease. Other countries do not breed the primates in such large numbers or to the standard produced in China.

"Some 95% of papers using transgenic monkeys come from China," says Bezard, director of the Institute of Neurodegenerative Diseases at the University of Bordeaux, and manager of his own lab at the Institute of Laboratory Animal Sciences, Chinese Academy of Medical Sciences. Among recent breakthroughs, researchers at the Chinese Academy of Sciences (CAS) have genetically modified cynomolgus monkeys so they exhibit autistic-like behaviours, to better understand what causes the disorder, and how to treat it. CAS scientists have also cloned primates using a technique similar to the one that produced Dolly the sheep. Bezard has used rhesus monkeys to show how brain–computer interfaces can restore leg movement after spinal cord injury.

These developments have coincided with improvements in the regulation and enforcement of international standards in the biosciences in China. Two events were critical to the process: the 2003 SARS outbreak, which put a spotlight on the issue of wildlife and lab animal management, and the creation in China of the world's first human–rabbit embryos in 2001, which provoked an international public relations crisis for the country.

The Chinese government recognizes that bioscience will play a major role in its global competitiveness. Biomedicine, synthetic biology and regenerative medical techniques are listed as strategic fields and industries in China's 13th Five-Year Plan. "China doesn't want to miss the life-science biotech revolution," says Cao Cong, an innovation studies researcher at the University of Nottingham Ningbo China.

Scientists have also realized that to gain