nature means these states are resistant to change, and thus stable to temperature fluctuations and physical distortion — features that could make them useful in devices.

Physicists have been investigating one class, known as topological insulators, since the property was first seen experimentally in 2D in a thin sheet of mercury telluride[4] in 2007 and in 3D in bismuth antimony a year later[5]. Topological insulators consist mostly of insulating material, yet their surfaces are great conductors. And because currents on the surface can be controlled using magnetic fields, physicists think the materials could find uses in energy-efficient 'spintronic' devices, which encode information in a kind of intrinsic magnetism of particles known as spin. But despite a decade of study, physicists have yet to find a topological insulator that has properties suitable for use in devices — for example, a material that is easy to grow, non-toxic and with tunable electronic states at room temperature.

The newly released catalogues classify all non-magnetic materials with known crystal structures by their topology, using methods published last year. Until now, physicists had largely relied on complex theoretical calculations to predict whether a specific material should harbour topological states. But in 2017, Andrei Bernevig, a physicist at Princeton University in New Jersey, and Ashvin Vishwanath, at Harvard University in Cambridge, Massachusetts, separately pioneered approaches[6,7] that speed up the process. The techniques use algorithms to sort materials automatically into databases on the basis of their chemistry and properties that result from symmetries in their structure. The symmetries can be used to predict how electrons will behave, and so whether a material is likely to host topological states.

"It's up to experimentalists to uncover new exciting physical phenomena."

Applying Bernevig's principles, a team led by researchers at the Beijing National Laboratory for Condensed Matter Physics scanned 39,519 materials and found more than 8,000 that are likely to have topological states. This includes both topological insulators and topological semimetals, which allow the study of new quantum phenomena and are being explored for use as catalysts. The team's database is available for anyone to access and can be search using a range of variables.

Bernevig and his colleagues also used their method to create a new topological catalogue. His team used the Inorganic Crystal Structure Database, filtering its 184,270 materials to find 5,797 "high-quality" topological materials. The researchers plan to add the ability to check a material's topology, and certain related features, to the popular Bilbao Crystallographic Server. A third group — including Vishwanath — also found hundreds of topological materials.

Experimentalists have their work cut out. Researchers will be able to comb the databases to find new topological materials to explore. "We now have a large database of candidate materials, and it's up to experimentalists to uncover new exciting physical phenomena," Yazyev says. ■

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AWARDS

Number-theory prodigy among winners of coveted maths prize

Fields Medals awarded to researchers in number theory, geometry and differential equations.

BY DAVIDE CASTELVECCHI

Number theorist Peter Scholze, who became Germany's youngest ever full professor at the age of 24, and geometrician Caucher Birkar — a Kurdish refugee — are among the winners of this year's Fields Medals, the most coveted awards in mathematics. The medals, which are given out every four years, were presented on 1 August; the other recipients were Alessio Figalli, whose research involves differential equations, and Akshay Venkatesh, who also works on number theory. The winners' names were announced in Rio de Janeiro, Brazil, at the opening of the International Congress of Mathematicians.

The Fields Medals, given out by the International Mathematical Union, are awarded to up to four mathematicians aged 40 or younger. For the first time in the medals' 82-year history, none of the awardees are citizens of the United States or France — two countries that together have netted nearly half of the medals so far. Maryam Mirzakhani, a winner in 2014, remains the only woman ever to receive the prize. (Mirzakhani died of cancer in 2017.)

PABLO COSTA/ICM2018

Fields medallists (left to right) Akshay Venkatesh, Peter Scholze, Alessio Figalli and Caucher Birkar.

Few observers doubted that Peter Scholze deserved a Fields Medal, or that he would win one this year. The 30-year-old became famous at 22 for finding a way to drastically shorten a book-length proof in arithmetic geometry.

Scholze is now a professor at the University of Bonn in Germany, and a director at the Max Planck Institute for Mathematics in the

same city. Most of his work has connections to '*p*-adic fields', exotic extensions of the ordinary number system that are useful tools for studying prime numbers. On the *p*-adics, he has built fractal-like structures called perfectoid spaces, which have helped to solve problems across several fields of mathematics, including geometry and topology. In recent months, Scholze has been checking a gigantic proof of the *abc* conjecture, one of the biggest unsolved problems in number theory. In 2012, the enigmatic Japanese mathematician Shinichi Mochizuki posted a proof online, but no one has yet been able to say definitively whether it checks out. Now, Scholze and a colleague, Jacob Stix, are said to have found a significant gap in the proof.

Caucher Birkar, 40, has made breakthroughs in the classification of algebraic varieties — geometric objects that arise from polynomial equations, such as $y=x^2$. He was born in 1978 in a region of western Iran dominated by the Kurdish ethnic group. Birkar recalls his childhood in video profiles of the Fields medallists: "My parents are farmers, so I spent a huge amount of time actually doing farming," he says. "In many ways, it was not the ideal place for a kid to get interested in something like mathematics."

In 2000, after studying at the University of Tehran, Birkar moved to the United Kingdom, where he got refugee status and, eventually, UK citizenship. He is now a researcher at the University of Cambridge. Birkar said that he hopes that his Fields Medal will put "just a little smile on the lips" of the world's estimated 40 million Kurds.

His win made headlines for more than just his research: before the award ceremony was over, his briefcase was stolen, with his medal in it. The organizing committee of the congress presented him with a replacement medal in a special ceremony on 4 August.

Akshay Venkatesh, who is 36, works on, among other things, classical problems in number theory, including number systems that consist of fractions of whole numbers and roots such as $\sqrt{2}$. He is among the few mathematicians who have made substantial progress on a question formulated by mathematician Carl Friedrich Gauss in the nineteenth century. Venkatesh was born in New Delhi and raised in Australia, and is currently at the Institute for Advanced Study in Princeton, New Jersey.

Compared with the other three medallists, 34-year-old Alessio Figalli works in an area that is closer to the real world: optimal transport, which seeks the most efficient ways to distribute goods on a network. Figalli, who is Italian and works at the Swiss Federal Institute of Technology in Zurich, applies the field to partial differential equations, which have several variables and most often arise in physics. ■

POLICY

German science goes under a microscope

Gigantic review of Helmholtz centres finds lack of diversity.

BY QUIRIN SCHIERMEIER

Germany's largest research organization is funding top-notch science, but it needs to employ more foreign and female researchers — and it is failing to leverage 'big data', such as electronic medical records.

These are the conclusions emerging from a first-of-its-kind evaluation of the Helmholtz Association of German Research Centres, which employs some 30,000 scientists and technicians at 18 centres and has an annual budget of €4.5 billion (US$5.3 billion).

Helmholtz showed *Nature* the results of the review, which individual centres will release over the next few weeks.

The results will serve as the basis for a strategic evaluation next year, which will be used to allocate research funding from 2021 to 2027. Other leading science organizations rarely, if ever, conduct such sweeping reviews, says neuroscientist Otmar Wiestler, president of the association.

DISCIPLINED ANALYSIS

"We were very impressed by the quality of the science," says Andrew Harrison, chief executive of the Diamond Light Source at the Harwell Science and Innovation Campus in Didcot, UK. He was one of more than 600 independent scientists from 27 countries who, between October 2017 and April 2018, spent up to a full week in Germany assessing the strengths and weaknesses of the organization's national research centres.

"As everywhere, the gender balance could be much better — but Helmholtz is aware of this and committed to improve it," adds Harrison.

In many fields — including biomedical research, condensed-matter physics and materials sciences — Helmholtz centres rank among the world's top institutes by quality of basic science and research infrastructures, reviewers concluded. Energy research and Earth and environmental sciences also received high marks.

In biomedical research, reviewers endorsed the organization's current focus on infectious diseases, diabetes, dementia and cancer. But specialized health-research centres in Munich, Braunschweig, Bonn and Heidelberg must make better use of patient data to develop diagnostic tools and therapies, the review concludes. It also recommends that the centres establish more designated clinical-trial units, in collaboration with hospitals, to take discoveries from the bench to practice.

"Like almost everywhere in science, real equity may still be generations away."

"Reviewers have clearly seen that Germany is lagging behind in digital medicine," says Wiestler. "It is absolutely vital for health research and health care in this country that we catch up."

A CHALLENGE TO DO BETTER

Reviewers also urged the organization to boost diversity. Efforts to that effect are already under way, says Wiestler. A €5.4-million initiative to recruit more female scientists was launched last year. It aims to increase the proportion of women in senior positions, from the current level of 19% to 24% by 2020.

To attract more foreign scientists — the organization employs around 6,000 right now — Helmholtz plans to establish an international research school in astronomy, in partnership with the National University of ▶

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