altmetrics on the repository. However, he says, "It's been evident for over two decades that the electronic format provides many new opportunities for measuring interest and importance." In that period, he adds, internal statistics show which articles on arXiv attract the general public's interest: "The numbers of downloads are far higher than those coming from within the research community." The data also show "instant spikes for articles with immediate research interest."

An *h*-index based on tweets?

The increasing popularity of open-access journals has been central to the rise of altmetrics, says Ben Wagner, a chemistry and physics librarian at the University at Buffalo. "Some studies show that an open-access article is downloaded twice as much as ones that aren't—and things that are open are easier to share."

Several open-access publishers are among the more than 540 scientific organizations and 12 000 individuals that have endorsed the 2012 San Francisco Declaration on Research Assessment, which calls for the elimination of journal-based hiring, promotion, and funding decisions. The declaration also advocates for the inclusion of nonarticle research output and "a broad range of impact measures" in research assessments.

But altmetrics data taken out of context run the risk of being "dangerous and inaccurate," says Rodrigo Costas Comesaña, an information scientist at Leiden University in the Netherlands. "You can calculate an *h*-index or impact factor based on tweets, but what would it mean?" At this point, he says, such metrics "may be useful for data mining, but probably not for evaluations."

Nevertheless, some scientists have begun to add altmetric data to their resumés and professional websites, which has heightened concerns about the potential for altmetrics to be intentionally inflated. As is the case with citation counts, says Adie, gaming altmetrics is going to happen, especially when incentives are attached. A safer approach, he notes, would be for researchers to use "a bucket of metrics, rather than just one metric from just one source."

Further research is needed to avoid the danger of altmetrics being misinterpreted or misused, says Stefanie Haustein, a postdoctoral information scientist at the University of Montreal. "A lot of events are being collected because they are easy to collect; our research will focus on giving these counts meaning." For example, she and University of Montreal professor Vincent Larivière have found moderate positive correlation between bookmark counts on Mendeley and citation counts reported by Scopus.

Unmapped territory

Efforts to establish standards and best practices for altmetrics are in the works. Last June the Baltimore-based National Information Standards Organization (NISO) released a report that contained 25 potential action items to address concerns about raw-data transparency and reproducibility, among other things. Working groups composed of representatives from the publishing industry, academia, and other relevant sectors are expected to complete their reports in time for NISO to publish its final recommendations next fall.

"We're pretty close to having an idea of best practices," says William Gunn, head of academic outreach at Mendeley and a participant in the NISO altmetrics project. There's consensus, he says, that the sources generating altmetric activity should be open and transparent, that raw data are preferable to a single score or indicator, and that the numbers should be put in context—for example, by comparing an article's tweet count to that of similar articles. One action item under discussion seeks agreement on the proper use of the term "altmetrics," or on using a different term. Haustein suggests "social media metrics" as one substitute. "[These metrics] are supplementary, not alternatives to citations," she says. "They won't replace citations."

In an October 2014 blog post titled "Altmetrics: What are they good for?" PLOS's Neylon wrote that altmetric data are "proxies of things we don't truly understand . . . and signals of the flow of information down paths that we haven't mapped." Patterns are emerging that "may let us determine not so much whether one piece of work is 'better' than another but what kind of work it is—who is finding it useful, what kinds of pathways is the information flowing down?"

"There is more to research evaluation than just citations," says University of Cambridge biochemistry postdoc Pietro Gatti-Lafranconi, an ImpactStory user and volunteer adviser. He says he likes ImpactStory because it allows him to combine "pure citation metrics with social media impact, in something that gets closer to the visibility of research."

Jermey N. A. Matthews

Brilliant new x-ray source is up and running at Brookhaven

The National Synchrotron Light Source II will produce intense beams to reveal details of complex materials.

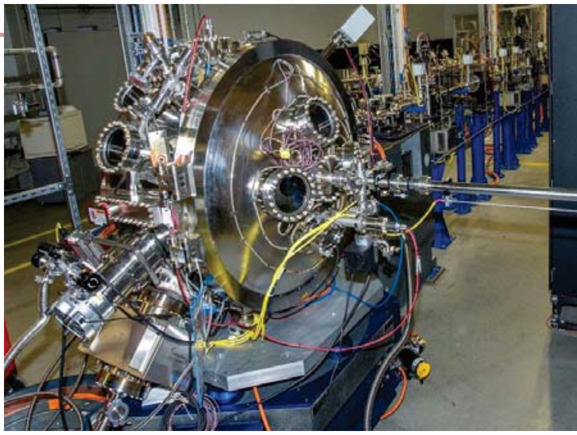
Although high-temperature superconducting cuprate materials were discovered nearly 30 years ago, scientists have yet to fully understand how they work. Now, with the $912 million National Synchrotron Light Source II (NSLS-II) coming on line at Brookhaven National Laboratory (BNL), researchers will have a new tool that could lead to a more complete theory of the mechanism by which the compounds become superconducting, says John Hill, x-ray group leader in BNL's condensed-matter physics and materials science group.

"The NSLS-II will be the most advanced synchrotron in the world when in full operation. It will have the most intense beams, will be the most stable, and will have the best instrumentation," says Steve Dierker, BNL's associate director for photon sciences. The new machine, under construction since 2009 (see PHYSICS TODAY, March 2009, page 24), will be capable of nanometer-scale measurements, a vast improvement over the NSLS's micron-scale resolution.

The higher brightness will also increase the experimental throughput and reduce the amount of time required for experiments. Brightness, or brilliance, is photon flux per second per unit bandwidth per unit area per unit solid angle. Intensity is the photon flux per second per unit bandwidth per unit area.

A wide energy spectrum

"We've developed new kinds of optics that we've demonstrated will focus down to 11 nanometers, and we see no showstoppers to advance that down to the nanometer level," says Dierker. At such a fine scale, experiments must be shielded from the smallest movements. The NSLS-II was built to dampen the vibrations coming from trucks on the nearby Long Island Expressway and



BROOKHAVEN NATIONAL LABORATORY

The Coherent Soft X-Ray Scattering beamline is the first of 60 to 70 beamlines planned for the National Synchrotron Light Source II. It will have scattering and imaging capabilities and detectors for probing correlated electronic textures and dynamics.

from ocean waves propagating through the sandy soil.

At an energy of 3 GeV, the electrons in the NSLS-II storage ring can efficiently radiate beams that range from the IR to hard x rays of more than 100 keV. “We explicitly chose 3 GeV because we wanted to supply not just hard or soft x rays but to cover the full range,” Dierker says. Other leading light sources aren’t as flexible, he notes. The Advanced Photon Source at Argonne National Laboratory, France’s European Synchrotron Radiation Facility, and Japan’s SPring-8 produce 6- to 8-GeV electrons, which are optimized for hard x rays. The Advanced Light Source at Lawrence Berkeley National Laboratory, on the other hand, is better suited for soft x rays, with its electrons of 1.8 GeV.

Most light-source users, including crystallographers and materials scientists, need x rays with energies of 10–25 keV, a range to which the NSLS-II is well suited, Dierker says.

As of press time, five NSLS-II beamlines had produced their first x-ray beams—an event known as first light. One of those, the Hard X-Ray Nanoprobe, will be used to examine IBM’s newest integrated circuit design, which has feature sizes of 10 nm. “We’ll be able to focus the x-ray beam down to the size of the features and measure the strain that comes from the lattice mismatch between the different materials, and also look at how that affects the electronic properties,” Dierker says. “And we’ll look at how those properties change when we’re pulling a current through it and the device is operating.”

Though difficult enough to measure in one dimension, the IBM samples will need to be moved and measured with nanometer resolution in six dimensions, three positional and three orientational, he notes.

A superconductor puzzle

Hill will be the initial user of the Coherent Soft X-Ray Scattering beamline. His team will look at what happens when they use doping to remove electrons from the copper in the cuprate high-T_c superconductors. The particular arrangement of missing electrons, or holes, determines if cuprates will transition from an insulator to a superconducting state, he says.

“At other synchrotrons, when we look at these arrangements of holes, there is a pretty weak signal, and it’s been hard to characterize them well. We hope at NSLS-II, where we have much more intensity, that we will do a much better job of learning where these arrayed patterns occur as a function of temperature and doping,” Hill says.

Ultimately, the NSLS-II will house 60–70 beamlines, says Dierker, though funding is available for only 30 so far. Eight beamlines were budgeted as part of the construction project. Another six, costing $90 million in total, are being financed separately through Department of Energy science programs.

An additional five beamlines will be dedicated to the life sciences. The National Institutes of Health has provided $45 million to build three beamlines, plus $5 million per year for their operation. The New York Structural Biology Center, a consortium of nine academic research institutions, is building a beamline, and Case Western Reserve University is building another.

Three beamlines will be built by NIST, which has been a constant partner since the NSLS’s origin 32 years ago. Dan Fischer, a physicist who heads a NIST team of researchers at BNL, says the first of those beamlines will begin operation late this year. It will feature a chemical x-ray photoemission microscope with 10-nanometer resolution and will be capable of probing the structure and chemistry of nanoscale systems such as carbon nanotubes and organic semiconductors.

Several of the instruments to be used on the NIST lines were built and tested at the old NSLS, but they were designed to take advantage of the NSLS-II’s intensity and brightness. One NIST microscope can image areas up to 2 cm^2 for spatial and chemical analyses. That’s useful for simultaneously imaging thousands of samples of electronic devices, DNA arrays, and biological materials such as skin, says Fischer. With the new beamlines, NIST researchers will work with about 200 industry, government, and academic partners on characterizing a variety of materials.

The remaining eight beamlines, which will include refurbished components from the NSLS, will be built with operational funds from DOE’s Basic Energy Sciences office. Suited for lower-intensity uses, those lines will provide a cost-effective way to quickly add experimental capacity to the NSLS-II, Dierker says. By fixing up and reusing the components—which include x-ray

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The National Synchrotron Light Source II will be the most brilliant source of synchrotron x rays in the world when it becomes fully operational in 2017.

mirrors; monochromators; end stations (the experimental apparatus for positioning the x-ray beam and sample in a controlled environment and for containing the detectors); and vacuum systems pumps, valves, and controllers—each beamline is costing about $4 million. Purchasing all-new equipment would have cost about $35 million more for all eight beamlines.

Once all 30 beamlines are operating around two years from now, the NSLS-II will host around 2000 researchers per year—about the same number of users as the predecessor ring accommodated, Dierker says. When fully built out with more than 60 beamlines, it will host more than 4000 users annually.

New protein discoveries

As with other DOE light sources, roughly 40% of NSLS users were life scientists. Sean McSweeney, photon science associate division director for structural biology at BNL, says two of the NIH beamlines will be dedicated to protein crystallography. The third will be used for x-ray scattering of noncrystalline materials and will address topics such as proteins in solutions and production of time-resolved images of protein complex formation.

The proteins that are located in cell membranes are key to cell signaling and control the entry and exit of drugs. But membrane proteins don't form large crystals, so high-resolution measurements of their structures are mostly beyond the range of lower-intensity x-ray sources. The NSLS-II x rays, 10 000 times more brilliant than those of the old NSLS, hold promise for subnanometer-resolution measurements of membrane protein crystals. Determining the composition of those complex molecules is critical to developing targets for new drugs, says McSweeney.

An additional advantage of the NSLS-II's tightly focused beams will be to minimize the amount of biological materials that are damaged by the x rays, McSweeney adds. The highly automated beamlines will use robotics to move crystals and liquid samples into and out of the beams. The delivery systems and controls for optimizing the beams will be simplified for nonexpert users, he says.

"We're dealing with flux densities that have not been achieved for crystallography beamlines before, so we're at the bleeding edge of what is known about how to do experiments. It's sort of scary," McSweeney says. Commissioning of the NIH beamlines will begin in about one year, and full operations should be under way in 18 months.

The extensive beamline installations planned for the next two years or so will limit available experimental time on the NSLS-II to 2000–2500 hours per year. After that, 5000 hours a year are anticipated.

Yet to be put into place are all of the computational resources that will be needed to handle the tens of terabytes of data generated during experiments. "In the old days, users would take their data home on a floppy disk, and nowadays on a memory stick, but that's not going to be possible," Dierker says. "We're going to have to develop a different paradigm where the data is collected here, probably stored here, and made accessible to the users." The concept is for the analysis routines to be hosted on-site so that users can work remotely and archive their data on BNL servers.

The DOE light sources are taking a lesson from the particle-physics community on how to cope with their big-data challenges, he says. Indeed, the NSLS-II is considering partnering with BNL's Relativistic Heavy Ion Collider program to help manage the problem.

David Kramer